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Injuries are the most serious health problem facing women in the military today. The overall goal of this study is to provide a comprehensive understanding of injuries to women in the military and to develop the basis for effective means to prevent specific injury problems. This study will begin with an analysis of data for serious injury (deaths and hospitalizations) in collaboration with Army, and later Navy investigators. Our work will expand the scope of their earlier studies and will then include injuries to women in the Air Force. In addition, a series of in-depth analytical studies will address specific injury problems in women (injuries related to alcohol, pregnancy, sports, training, etc.), using the ability to link records both within a single database and across different sources of data.

Drawing on our extensive experience analyzing injuries in civilian databases, this study is the first in-depth analysis of injuries to women in the military and will combine denominator data with numerator data from hospitalizations, fatalities, and lost-time injuries. These analyses will provide a better understanding of the unique injury hazards to women in the military and will form the basis for the development of sound prevention policies.

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FOREWORD

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N/A In conducting research using animals, the investigator(s) adhered to the "Guide for the Care and Use of Laboratory Animals," prepared by the Committee on Care and Use of Laboratory Animals of the Institute of Laboratory Resources, National Research Council (NIH Publication No. 86-23, Revised 1985).

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INJURIES TO WOMEN IN THE MILITARY
GRANT #DAMD17-95-1-5066

YEAR 3 ANNUAL REPORT

OCTOBER 1997 - OCTOBER 1998

INTRODUCTION:

Injuries are the most serious problem facing women in the military today. While the role of women has been increasing in the military, limited consideration has been given to how injuries may differ from their male counterparts. Injuries are the leading cause of death for all women less than 35 years of age, however the specific problems of injuries to women have not been well studied in either civilian or military populations. The comprehensiveness of the military data provide a unique opportunity for study that encompasses both occupationally-related injury as well as injuries that personnel incur while they are not on duty. Both types of injuries result in significant costs to the military and may have major impacts on troop readiness.

THIRD YEAR PROJECT ACTIVITIES: October 1997-1998:

Activities during year three have involved further exploration of the data that have been made available to the investigators, and analyses contributing to definitive research. We have also continued our efforts to acquire important data sets.

RESULTS OF RESEARCH EFFORTS:

Reports

Amoroso PJ, Yore MM, Smith GS, Lopez M. Analysis of military occupational specialties and hospitalizations; Part 1: 25 largest Army enlisted occupations. U.S. Research Institute of Environmental Medicine Technical Note No. 98-7. Natick, MA. December 1997.

Lincoln AE. The influence of smoking on disability following hospitalization for musculoskeletal disorders. Dissertation submitted to the School of Hygiene and Public Health, Johns Hopkins University. 1998. (Appendix A - Abstract).

Alsip BJ. Unintentional injury mortality in the U.S. Army: 1993-1995. Report prepared for M.P.H. degree, Johns Hopkins University 1998. (Appendix B).

Copley GB. A personnel system administrative database analysis of U.S. Air Force mortality data using the STANAG code, prepared for Ph.D. degree, Johns Hopkins University. 1998. (Appendix C - Abstract).

Articles Submitted

Smith GS, Dannenberg AL, and Amoroso PJ. Hospitalization due to injuries in the military: evaluation of current data and recommendations for its use in injury prevention. American Journal of Preventive Medicine. In press. (Appendix D - Abstract).

Lauder TD, Baker SP, Smith, GS, and Lincoln AE. Sports and physical training injury hospitalizations in the army. American Journal of Preventive Medicine. June 1998 In review. (Appendix E - Abstract).

Lincoln AE, Baker SP, and Amoroso PJ. The Use of Existing Military Administrative and Health Databases for Injury Research. American Journal of Preventive Medicine. In review. (Appendix F).

Nicole S, Bell NS, Amoroso PJ, Yore MM, Smith GS, and Jones BH. Self-reported risk-taking behaviors and hospitalizations for motor vehicle injury among active duty army. Submitted American Journal of Preventive Medicine. (Appendix G - Abstract).

Completed Articles Under Revision

Lincoln AE, Smith GS, Amoroso PJ, and Hinton RY. The Association Between Musculoskeletal Conditions, Disability, and Smoking: A Review of the Literature. (Appendix H - Abstract).

Lincoln AE, Smith GS, Amoroso PJ, and Bell NS. The Natural History and Risk Factors of Musculoskeletal Conditions Resulting in Disability Among U.S. Army Personnel. (Appendix I - Abstract).

Lincoln AE, Smith GS, Amoroso PJ, and Bell NS. The Effect of Cigarette Smoking on Musculoskeletal-Related Disability. (Appendix J - Abstract).

Wong TY, Smith GS, Lincoln AE, Tielsch J. Hospitalized Ocular Injuries in the United States Army -- 1985-1994. (Appendix K - Abstract).

Abstracts and Papers Presented

Smith GS, Lincoln AE, Baker SP: Use of Surveillance Databases for Analytic Research: Hospital Databases in the Army. Abstract presented at the National Occupational Injury Symposium, Morgantown, WV. October 1997.

Lincoln AE, Baker SP, Smith GS: The Effect of Workers Compensation Likelihood on the Reporting of Cumulative Trauma Disorders. Abstract presented at the National Occupational Injury Symposium, Morgantown, WV. October 1997.

Smith GS, Lincoln AE: Hospitalization for Musculoskeletal Conditions: Comparisons Among Army and Civilian by Gender. Abstract presented at the Fourth World Conference on Injury Prevention and Control, Amsterdam, The Netherlands. May 1998.

Lincoln AE, Smith GS, Amoroso PJ, and Bell NS. The Natural History of Musculoskeletal Conditions Resulting in Disability Among U.S. Army Personnel. Abstract presented at New England Occupational Injury Research Group 1998 Symposium, Hopkinton, MA. May 1998.

Papers in Preparation

Amoroso PJ, Smith GS, Bell NS. Cause-of-injury Coding in Military Hospitals: Comparisons and validation of STANAG 2050 vs. ICD-9 CM E-Codes.

Smith GS, Lincoln AE, Hinton RY, Amoroso PJ. The Epidemiology of Musculoskeletal Conditions in the U. S. Army, 1989-1994.

Smith GS and Breugelmans JG. Injuries to Women in Pregnancy.

Smith GS and others. Gender Differences in Ocular Injury in the U.S. Army by Occupation.

Smith GS and others. Risk Factors for Female Homicide.

Baker SP. Overview of Female Active Duty Mortality

Copley GB. Association Between Certain Risk Factors such as Alcohol Use and Injury Outcomes in the Air Force.

Copley GB. STANAG Coding for Air Force Deaths: FY 1989 - FY 1996.

DATA STATUS:

Hospitalization and personnel data from the Total Army Injury and Health Outcomes Database (TAIHOD) from the Army Research Institute of Environmental Medicine have been used in various analytical studies.

In this fiscal year, we received hospitalization and personnel data from the Air Force for FY1989 - FY1996. Descriptive analyses have been completed on the hospitalization data, and we expect to have this data set linked with the demographic data in the near future.

The Defense Manpower Data Center (DMDC) is currently extracting personnel variables for all branches of the military for FY 1989 through FY 1998. This data will provide us with a uniform set of demographic elements.

The Directorate for Information, Operations, and Reports (DIOR) continues to provide support for the project through the sharing of DD1300 data (Appendix L). Further consultation with the DIOR will hopefully provide information regarding mortal events to women who expire within 120 days of their injuries but are retired from active duty status immediately following the trauma.

The 528 female deaths reported between FY 1989 and FY 1996 are now being coded using both the military STANAG Code and the ICD9 cause and nature of injury codes. Other data fields on the DD1300 not previously entered electronically have been added to enhance the investigators understanding of female mortality. These new data fields include the duty status, hazardous duty pay, and pilot/nonpilot status in the case of aircraft-related events.

Mortality data were also obtained from the individual branches of the military this last fiscal year through the Casualty Service Assistance offices. With this new mortality information, we hope to augment the DD1300 data in such areas as the manner of injury. This additional data may be especially useful in, for example, cases of intentional death where the assailant was identified by the victim.

- A record review, arranged by Mr. David Greco, Head of the Navy Casualty Office at the Bureau of Naval Personnel, permitted a broader understanding of how death data is gathered and maintained.

- The Marines and Air Force provided copies of the Casualty Report Forms.

- The Army Casualty Office provided in tabular form, data pertaining to female active duty deaths for our study period.

RESEARCH SUBJECT CONFIDENTIALITY:

In order to ensure confidentiality of patient records, the social security numbers of living active duty military personnel continue to be scrambled by a method developed by the Grant's Officer Representative (GOR), LTC Paul Amoroso of USARIEM. With the exception of mortality data, the Hopkins study team continues to receive only encrypted data from the various services and agencies supporting our research effort. The purpose of this encryption process is correct record linkage across the various resources, particularly hospitalization and personnel data.

Appendix A

THE INFLUENCE OF SMOKING ON DISABILITY FOLLOWING HOSPITALIZATION FOR MUSCULOSKELETAL DISORDERS

by

Andrew E. Lincoln

DISSERTATION

submitted to the School of Hygiene and Public Health

of The Johns Hopkins University in conformity

with the requirements for the degree of

DOCTOR OF SCIENCE

Baltimore, Maryland

1998

ABSTRACT

Statement of the Problem:

Musculoskeletal disorders are a primary source of morbidity, lost time, and lost readiness in the military. The combined categories of injuries and musculoskeletal/ connective tissue disorders account for the largest proportion of hospitalizations in the U.S. Army (30%) and the leading cause (51%) of diagnoses resulting in discharge from the service because of disability. Despite the high incidence of these disorders and the tremendous lifetime costs associated with permanent disability (an average of $277,000 per case), little is known about their natural history and long-term outcomes, the likelihood that they will result in permanent disability necessitating medical discharge, or those factors associated with an increased likelihood of disability.

Purpose:

The purpose of this research was to investigate risk factors for the development of physical disability following the incidence of a musculoskeletal disorder. The natural history of various diagnostic categories was described from the point of initial hospitalization to the outcome of medical discharge from the service for disability. In addition, potential risk factors that may contribute to this outcome were studied. In particular, the role of smoking was investigated among each of the diagnostic categories to determine whether there was variation in smoking's effect and which diagnoses were more susceptible to those effects.

Methods:

This retrospective cohort study made use of four types of data: demographics, health behavior and practices, health outcomes (hospitalizations), and functional outcomes (disability ratings). Five separate databases containing these data were linked: personnel, hospitalization, health risk appraisal, disability, and loss from service. Data were obtained from the Total Army Injury and Health Outcomes Database (TAIHOD), a collection of databases that was recently created primarily for injury prevention and women's health research. Unique identifiers (scrambled social security numbers) enabled the linkage of information across databases, in effect permitting me to track the natural history of a subject's condition. This study assessed the roles of demographic, behavioral, psychosocial, occupational, and clinical characteristics in the development of physical disability. Subjects included 15,268 U.S. Army personnel hospitalized for a common musculoskeletal condition between the years 1989-1996 who had completed a health risk appraisal and were followed through 1997. The cohort did not include persons hospitalized for all musculoskeletal conditions or injuries, but only those with certain well-defined diagnostic categories. Survival analyses involved Kaplan-Meier estimates of cumulative survival, log-rank tests for equality and trend, and Cox proportional hazards models.

Results:

The initial review of the literature (presented in this dissertation as a review paper) identified smoking to be a significant risk factor for low-back pain (OR

ranging from 1.2-3.0), lower extremity injury (1.9), carpal tunnel syndrome (1.6), and fracture/non-union (4.1-7.9). The epidemiologic evidence relating tobacco use to the incidence of acute injuries or musculoskeletal disorders and its influence on healing was examined. In addition, potential physiological and psychosocial mechanisms of action of tobacco and how it may influence the risk of developing a physical disability were addressed. A multifactoral model illustrating the transition from musculoskeletal disorder to physical disability was presented in an effort to better understand potential predictors of disability resulting from musculoskeletal disorders.

Results from the first analytic set of analyses identified an overall disability discharge rate of 9.5 discharges for every 100 persons hospitalized for the conditions chosen. Back conditions had the greatest 5 year cumulative risk of disability following hospitalization (21%, 19%, and 17% for intervertebral disc displacement, intervertebral disc degeneration, and nonspecific low back pain). Causes of disability were multiply determined with risk factors found to include older age, less education, lower pay grade/rank, shorter or intermediate length of service, recurrent hospitalization, heavy cigarette smoking, lower job satisfaction, and greater work stress. Among females, only covariates indicating less education, shorter length of service, lower job satisfaction, and specific diagnoses (e.g., disc displacement, malunion/nonunion) were identified as significant, although there were substantially fewer female subjects than male subjects (2246 versus 13,013). The factor with the greatest associated risk of developing disability among men was for those with "other" musculoskeletal conditions who were 35+ years old relative to <21 years old (relative hazard = 29.3, 95% confidence interval: 3.7, 230.0). For women who had a

knee condition, having a high school education was the greatest risk factor for developing disability relative to those with college degrees (relative hazard = 8.8, 95% confidence interval: 2.7, 28.7). Factors not significantly associated with the development of disability were race/ethnicity, marital status, number of dependents, alcohol use, body mass index, and health practices index. Also, terms that addressed the potential interaction of cigarette smoking, alcohol use, work stress, job satisfaction, age group, and length of service were found not to be statistically significant.

Findings from the second set of analyses indicated an association between smoking level and disability discharge when all musculoskeletal categories were combined. Kaplan-Meier estimates illustrated distinct survival curves among different smoking levels and log-rank tests demonstrated dose-response associations between increased smoking level and cumulative risk for disability discharge for all knee disorders (e.g., meniscal injury ($p<0.001$), cruciate ligament injury ($p=0.08$), collateral ligament injury ($p=0.003$), and chondromalacia ($p=0.03$)), rotator cuff injury ($p=0.01$), and intervertebral disc displacement ($p=0.05$). However, when adjusting for stronger predictors in multivariate Cox proportional hazards models such as age group, sex, and length of service, smoking was significantly associated with only meniscal injuries (light smokers had a 44% greater risk than nonsmokers and heavy smokers had a 49% greater risk) and all musculoskeletal categories combined (heavy smokers had a 21% greater risk). Smoking was also associated with disability among persons with carpal tunnel syndrome, rotator cuff injury, collateral ligament injury, and chondromalacia, although not at statistically significant levels.

Former smokers appear to be protected for all musculoskeletal categories combined, though not significantly (RH=0.94, 95% CI: 0.80, 1.11). Overall, the attributable risk of disability due to smoking among current smokers and nonsmokers was 18%, while among current smokers with meniscal injuries, 38% of disability discharges were attributable to smoking.

Conclusion:

The review of the literature provides a sound biological basis for smoking to affect tissue blood supply and other factors affecting the healing process and, consequently, the likelihood of progression to disability. The meniscus is particularly likely to be affected as it has limited vascularization that penetrates only its peripheral 10-25%. Thus, smoking's effect of reducing blood flow may further limit the supply of nutrients to the damaged tissue.

This study successfully demonstrated that it is possible to link large existing administrative databases for the epidemiological study of injury and disability and provides a useful model for future studies. This population-based, retrospective cohort study strongly suggests an association between smoking and the development of disability for meniscal injuries based on multivariate analysis and a high attributable risk. The findings also suggest that a smoking cessation intervention among Army personnel who injure their menisci may serve as an important means to prevent the development of disability, especially since the effect seems to be reversible as former smokers have risks similar to nonsmokers.

Although smoking was found to be the single significant behavioral predictor

of disability, smoking cessation is particularly difficult to achieve in the military. Prevention and cessation efforts must overcome a long history of condoning and even encouraging smoking, the popular image of macho soldiers with cigarettes, and the tendency for personnel to initiate or resume smoking in order to assert their individuality or relieve stress. However, the recent development of tailored intervention programs for military personnel and the involvement of physicians trained in smoking cessation counseling may offer an additional mechanism to reduce the development of disability and the many other ill effects associated with smoking.

Unintentional Injury Mortality in the U.S. Army: 1993-1995

MPH Integrating Experience
550.866

Bryan J. Alsip

ABSTRACT

Preventable injuries cause a significant number of unnecessary deaths in the United States Army every year. However, U.S. Army injury fatality rates by specific location are not well-documented. Unintentional injury death rates by cause and state were calculated to study whether certain geographical areas were associated with very high or very low rates. A descriptive analysis was performed to investigate unintentional injury fatality rates by state in the U.S. Army during the years 1993-1995 for soldiers stationed within the United States. The average rate for all states combined decreased each year during this period. Arkansas, Wisconsin, Utah, Illinois, New Mexico California, Pennsylvania, Alaska, Missouri, Texas, North Carolina, New York, Indiana, and Oklahoma all exhibited rates that were significantly higher than the U.S. average rate during these years. States with unintentional injury death rates significantly lower than the U.S. average during this time included Massachusetts, New Jersey, Hawaii, and the District of Columbia. Specific injury rates by cause and location were examined for the year 1994. During 1994, motor vehicle accidents represented over half of all unintentional injury fatalities for U.S. Army personnel. The analysis also reveals incompatibilities between in current U.S. Army population and injury surveillance databases. Modifications in the databases may facilitate the calculation and analysis of specific injury rates by cause and specific installation. This could allow the Army to better understand and implement effective and targeted preventive strategies.

INTRODUCTION

Injuries are known to be a major public health problem in the United States. In terms of mortality, injuries are the third leading cause of death in the U.S. and result in the loss of about 150,000 lives each year (2). Among persons under the age of 45, injuries are the leading cause of death. Unintentional or accidental injuries

are often categorized separately from homicide and suicide. Death rates for all unintentional injuries in the U.S. vary with age, being highest among the oldest ages with an intermediate peak at ages 20-24. Death rates for all unintentional injuries also vary by gender; males have higher rates of death than females (2).

Similar to the civilian sector, injuries in the U.S. Army are a significant source of human suffering and increased monetary costs, both direct and indirect. Injuries also contribute to increased loss of time from work and training, and decreased military readiness. Studies have shown that injuries are the most important cause of preventable morbidity in active duty soldiers in the U.S. Army (13). In general, men have been found to be at greater risk than women for most types of injuries. However, several military and civilian reports suggest that when exposure to risks are controlled, women are at greater risk of experiencing an injury during training and sports activities (1,6,7,11). Studies that examined injury rates during U.S. Army basic combat training also found that females appear to be at greater risk of lower extremity injury than males (1,16). Many articles have also examined risk factors and gender-specific rates among military personnel for certain types of injury such as parachuting and exercise-related injuries (1,4,7-10,14,16). Nevertheless, data are scarce concerning specific rates of unintentional injury fatalities in the U.S. military by unit location or state.

The purpose of this study was to compare rates of unintentional fatal injuries during 1993, 1994, and 1995 among active duty Army personnel stationed throughout the U.S. by state. These comparisons are used to determine if there is any evidence of high or low rates of unintentional injury death among U.S. Army personnel when compared to data for the U.S. population as a whole. State data

were examined further to delineate the causes of unintentional injury fatalities during 1994. This information may provide guidance for targeted prevention measures at specific U.S. Army training locations throughout the country.

METHODS

The Data

Mortality data were obtained from the Directorate for Information, Operations, and Reports (DIOR), Statistical Information Analysis Division. In the U.S. military, deaths are reported on Department of Defense (DD) Form 1300, "Report of Casualty." All personnel who die on active duty are reported through this system regardless of the location of the incident or whether the soldier was on or off-duty. All deaths that occurred and were reported to the Directorate for Information, Operations, and Reports for the years 1993, 1994, and 1995 were evaluated.

Variables in this database available for analysis included the following: service; casualty place–listed by state; casualty manner–listed as Accident, Hostile Action, Homicide, Illness, Suicide, Terrorist Activity, Determination Pending, or Unknown; pay grade; duty status; casualty status (dead); casualty date; casualty type–hostile or non-hostile; date of birth; race; sex; ethnic group; religion; occupation code or Military Occupational Specialty (MOS); casualty category; body status; age; home state; home city; and rank.

Unintentional injuries were selected from the mortality database as those listed as "Accident." These fatalities were tabulated for years 1993, 1994, and 1995. For the 1994 mortality data, these non-suicide, non-homicide incidents were given a short description such as Automobile (POV), Government Vehicle, Fire/Burns,

Drowning, Airplane, etc. This coding allowed a more specific analysis of the mortality rates for each state by cause for that year.

Personnel data were obtained from the Total Army Injury and Health Outcomes Database (TAIHOD) created at the U.S. Army Research Institute of Environmental Medicine (USARIEM). This database connects several military health outcome data sources. It contains demographic information on all active duty Army personnel such as age, gender, and rank. Within this database, the actual location of personnel is indexed only by the zip code of the unit to which that person was stationed. From this database, a listing of all U.S. Army personnel by unit zip code was extracted. The anonymity of all injured soldiers was safeguarded by using aggregate data only. No individual soldiers were identified at any time.

To estimate the total number of Army personnel in each state, a listing of all U.S. Army installations was obtained from the Department of Defense Legacy Resource Management Program (5). This information was supplemented by the *Guide to Military Installations* (3). These sources provided a listing of all Army installations in the United States and their respective zip codes. The total number of U.S. Army personnel listed by state was then estimated by using a compilation of all personnel in each zip code that was listed for each U.S. Army installation in that state in 1994. Comparing total personnel figures generated using this method with the total figure listed for all soldiers listed in the personnel database resulted in capture of over 80% of all U.S. Army personnel in the United States.

Analytic Methods

Total rates of unintentional injury deaths were calculated for each state for the years 1993, 1994, and 1995. These were estimated by dividing the number of

unintentional injury deaths for each state in each year by the estimated number of personnel in each state in 1994. Estimates of total troop strength were fairly consistent during the years 1993-1995. Therefore, the 1994 personnel data were considered to be good estimates for the denominators in the rate calculations for all three years.

For some states where the estimated number of personnel stationed was so small, even one or two unintentional injury deaths resulted in extremely high rates. Because of this, further analysis was performed to calculate an average unintentional injury death rate by state for all three years. Thus, numerators were calculated by combining the total number of deaths during all three years for each state. Denominators were estimated by multiplying the total installation figures for each state by three for a three-year combined figure. Average unintentional injury death rates during the three-year period for each state were then calculated by dividing the combined numerator values by the three-year estimate of population denominators. To allow some determination of statistical significance in the comparison of unintentional injury death rates, 95 percent confidence intervals for the average rate of each state were generated using STATA assuming a poisson distribution.

A compilation of unintentional injury fatalities, by cause, was then generated for all states in which data were available for 1994. Each cause of unintentional injury death was calculated as a percentage of the total number of all unintentional injury deaths during 1994.

RESULTS

Table I displays for each state the number of unintentional injury deaths and the unintentional injury death rate per 100,000 soldiers stationed in U.S. Army installations during the years 1993, 1994, and 1995. The twenty-eight states and the District of Columbia that comprise this group represent all U.S. States with Army installations, all reported at least one unintentional injury mortality during these years. The average annual unintentional injury fatality rate appears to have decreased each year from 39 deaths per 100,000 soldiers in 1993 to 37 in 1994, to 31 by 1995. Using these figures and the method of analysis outlined above, a three-year average unintentional injury death rate was calculated for each state. These results are displayed in **Table II** along with 95% confidence intervals for each mean rate. The overall unintentional injury death rate for all states containing U.S. Army installations was 35.7 deaths per 100,000 soldiers. The age-adjusted total average rate for the United States during 1993 to 1995 was 29.7 deaths per 100,000 population for the same years (12). States with unintentional injury death rates higher than 29.7 and whose confidence intervals did not include this figure included: Arkansas, Wisconsin, Utah, Illinois, New Mexico California, Pennsylvania, Alaska, Missouri, Texas, North Carolina, New York, Indiana, and Oklahoma. The rates for these states are displayed in **Figure 1**. States with unintentional injury death rates lower than 29.7 and whose confidence intervals did not include this figure included: Massachusetts, New Jersey, Hawaii, and the District of Columbia. The rates for these states are displayed in **Figure 2**.

Table III displays the number and percentage of all causes of unintentional injury death reported during 1994. **Figure 3** displays the percentages of unintentional injury deaths associated with motor vehicles, airplanes, motorcycles, and all other categories combined. Almost half of all of these deaths were due to

accidents involving privately owned vehicles (POV's). This statistic increases by another 5% if government vehicles are included in the calculations. The second most common unintentional injury death in 1994 were those associated with airplane accidents. **Table IV** displays the number of all causes of unintentional injury death during 1994 for all states with personnel stationed at U.S. Army installations. Accidents involving privately owned vehicles represented at least 50% of all unintentional injury fatalities in 15 states. The states of Alabama, Massachusetts, New Jersey, and Wisconsin reported no unintentional injury deaths during 1994.

DISCUSSION

Unintentional injury fatality rates in the U.S. Army decreased during the years 1993 to 1995. The overall unintentional injury death rate for all states containing U.S. Army installations was 35.7 deaths per 100,000 soldiers. Although this was higher than the age-adjusted total average rate for the United States during 1993 to 1995, confidence intervals for the Army rate included the average U.S. rate suggesting that it is not significantly higher. One might argue that these higher rates are consistent with the nature of occupational hazards within the armed forces. It would be helpful to examine data from other years to see if these declining rates are a consistent trend in the Army. Furthermore, although the Army rates would have to be age-adjusted for a valid direct comparison.

Several states exhibit extremely high rates as a result of comparatively small denominators. States such as Arkansas, Illinois, New Mexico, Utah, and Wisconsin all reported total U.S. Army active duty populations of fewer than 1,000 soldiers resulting in very high rates. Examination of the calculations for the three-year

interval 1993-1995 does reveal several states with statistically significant rates. Of these, Arkansas, Wisconsin, Utah, Illinois, New Mexico California, Pennsylvania, Alaska, Missouri, Texas, North Carolina, New York, Indiana, and Oklahoma all exhibited rates that were significantly higher than the age-adjusted total average rate for the United States of 29.7 deaths per 100,000 population. Further investigation of the installations located within these states is warranted to determine whether there are environments or activities which may benefit from specific prevention measures. States whose three-year average unintentional injury death rates that were statistically lower than the average rate for the United States and whose confidence intervals did not include this figure included: Massachusetts, New Jersey, Hawaii, and the District of Columbia. A more detailed investigation of these states is also justified to determine whether there are systematic reasons for such lower rates and whether they are consistent through a longer period of observation.

States such as Wisconsin, New Mexico, Missouri, North Carolina, Indiana, and Oklahoma may be particularly revealing since these states incorporate only a single U.S. Army installation. Examination of the factors involved in these rates are therefore narrowed to a specific installation rather than the entire state. Identification of successful strategies for unintentional injury fatality prevention in these locations could be useful at other U.S. Army facilities, particularly those with high death rates. It is also important to consider other confounding variables in terms of unintentional injury deaths such as age, gender, occupation. Also, conclusions may also be affected when considering the relatively small numbers of unintentional injury deaths.

When examining the unintentional injury deaths by cause for all states in 1994, the majority reported unintentional injury deaths associated with automobile accidents as the most frequent cause. In fact, automobile crashes, involving privately

owned or government vehicles, represent approximately 53% of all the unintentional injury fatalities by cause for all states combined. This is similar to national data where motor vehicle crashes generally represent half of all unintentional injury deaths in the U.S. (2).

One notable deviation from national figures is the percentage of unintentional injury deaths in the Army due to airplane crashes. These represent over 16% of all unintentional injury fatalities compared with the approximately 2% seen in national statistics (2). A proportion such as this may have been skewed by a particularly large crash in a given year, and thus should be examined to see if it is a reliable figure. For example, on 23 March 1994, a collision between an F-16 fighter jet and a C-130 transport plane at Pope Air Force Base in North Carolina resulted in a large number of U.S. Army casualties (15). In fact, according to the mortality data, all 21 Army deaths in North Carolina associated with airplane accidents were reported to have died as a result of an incident on the same date as this one crash. Further investigation of the incident reveals that no one aboard either of the two planes was actually hurt. The casualties, and all of the fatalities, were paratroopers who were on board or about to board a third aircraft–a C-141 transport plane–that was on the ground. After the air collision, the F-16 exploded and hit the ground. Part of this debris hit the C-141 causing its fuel tanks to burst into flames while more of the flaming debris hit a shed on the tarmac where paratroopers were gathered (15). Prevention measures addressing the issue of decreasing unintentional injury deaths associated with airplane accidents should therefore take all of these factors into consideration. It also should be noted that soldiers may be flying under more hazardous situations and in less optimal environments than the majority of the general U.S. population.

The validity of these findings depends largely on the assumptions used to calculate population figures. All active duty U.S. Army personnel are not stationed solely within U.S. Army installations. Many of these soldiers are located in areas unaccounted for when using only personnel stationed at U.S. Army forts. Were all of these data included, as could be done with an electronic database that lists all zip codes by state, most, if not all of the personnel totals would be increased. Therefore, subsequent calculations of the unintentional injury death rates for the U.S. Army would be lower than what was found in this study. Additionally, the location of unintentional injury deaths does not necessarily correspond to the area to where the soldier is stationed, particularly if such incidents happen off-duty or while on leave. Several unintentional injury deaths listed in the DIOR database occurred in states where there are no U.S. Army installations.

Furthermore, because fatalities in the DIOR database are only listed by the state in which they occurred, one cannot determine which specific unit location has a higher risk for fatalities. As stated previously, in states with only one U.S. Army installation, one can make inferences regarding those forts, but such methods are still limited. A particular recommendation of this study is to begin recording the exact location of the fatality in the database by zip code, not just state, so that these figures can be more easily matched with current population data to calculate location-specific fatality rates. These rates could then be used to identify specific areas for targeted prevention measures or to document and replicate successful strategies. In view of the high rates of preventable mortality due to unintentional injuries, this information would be extremely helpful in saving lives and conserving the fighting strength of the U.S. military.

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Appropriate journals where article might be published:

- *Military Medicine*
- *American Journal of Public Health*
- *American Journal of Preventive Medicine*

Table I Unintentional Injury Deaths and Death Rates per 100,000 U.S. Army Soldiers by State, 1993-1995

STATE	Death Rates 1993	Death Rates 1994	Death Rates 1995	Number of Deaths 1993	Number of Deaths 1994	Number of Deaths 1995	Installation Personnel
Alabama	64	0	55	7	0	6	10901
Alaska	94	59	47	8	5	4	8540
Arizona	26	26	65	2	2	5	7667
Arkansas	3093	3093	1031	3	3	1	97
California	151	94	66	16	10	7	10617
Colorado	13	30	17	3	7	4	22987
DC	21	10	0	2	1	0	9621
Georgia	26	19	17	15	11	10	57289
Hawaii	19	9	9	4	2	2	21390
Illinois	462	231	231	2	1	1	433
Indiana	67	67	0	1	1	0	1494
Kansas	28	19	23	6	4	5	21359
Kentucky	31	12	14	13	5	6	41640
Louisiana	28	35	35	4	5	5	14295
Maryland	11	43	22	1	4	2	9285
Massachusetts	54	0	0	1	0	0	1852
Missouri	35	128	23	3	11	2	8597
New Jersey	38	0	0	1	0	0	2662
New Mexico	116	231	116	1	2	1	864
New York	49	56	35	7	8	5	14310
North Carolina	26	70	44	13	35	22	49783
Oklahoma	67	22	45	12	4	8	17947
Pennsylvania	93	186	0	1	2	0	1074
South Carolina	34	9	34	4	1	4	11635
Texas	49	51	46	28	29	26	56643
Utah	990	495	0	2	1	0	202
Virginia	27	27	16	5	5	3	18625
Washington	22	33	22	4	6	4	18183
Wisconsin	1130	0	1130	2	0	2	177
All States*	39	37	31	171	165	135	440169

*Summary value for states listed above which contain at least one U.S. Army installation

Table II: Average Unintentional Injury Death Rates per 100,000 U.S. Army Soldiers by State for the Three-Year Period 1993-1995

STATE	Deaths*	Population**	Death Rate***	95%	CI****
Alabama	13	32703	39.8	28.6	54.5
Alaska	17	25620	66.4	51.0	84.0
Arizona	9	23001	39.1	27.7	53.3
Arkansas	7	291	2405.5	2309.8	2503.0
California	33	31851	103.6	85.0	126.0
Colorado	14	68961	20.3	12.2	30.9
DC	3	28863	10.4	4.8	18.4
Georgia	36	171867	20.9	12.2	30.9
Hawaii	8	64170	12.5	6.9	22.2
Illinois	4	1299	307.9	274.6	344.4
Indiana	2	4482	44.6	32.8	60.2
Kansas	15	64077	23.4	4.8	34.5
Kentucky	24	124920	19.2	11.4	29.7
Louisiana	14	42885	32.6	22.7	46.3
Maryland	7	27855	25.1	16.2	36.9
Massachusetts	1	5556	18.0	10.7	28.4
Missouri	16	25791	62.0	47.5	79.5
New Jersey	1	7986	12.5	6.9	22.2
New Mexico	4	2592	154.3	130.6	180.3
New York	20	42930	46.6	34.5	62.5
North Carolina	70	149349	46.9	34.5	62.5
Oklahoma	24	53841	44.6	32.8	60.2
Pennsylvania	3	3222	93.1	75.1	113.9
South Carolina	9	34905	25.8	17.0	38.1
Texas	83	169929	48.8	36.2	64.8
Utah	3	606	495.0	452.3	540.6
Virginia	13	55875	23.3	14.5	34.5
Washington	14	54549	25.7	17.0	38.1
Wisconsin	4	531	753.3	700.2	808.8
All States	471	1320507	35.7	25.2	49.8

*Three-year total unintentional injury deaths reported
**Three-year combined population figure
***Overall death rate per 100,000 soldiers for the three-year period
****CI's for Death Rates calculated using poisson distribution

Figure 1

Average U. S. Army Unintentional Injury Death Rates by State
for States with Rates Significantly Higher than the U.S. Average, 1993-1995

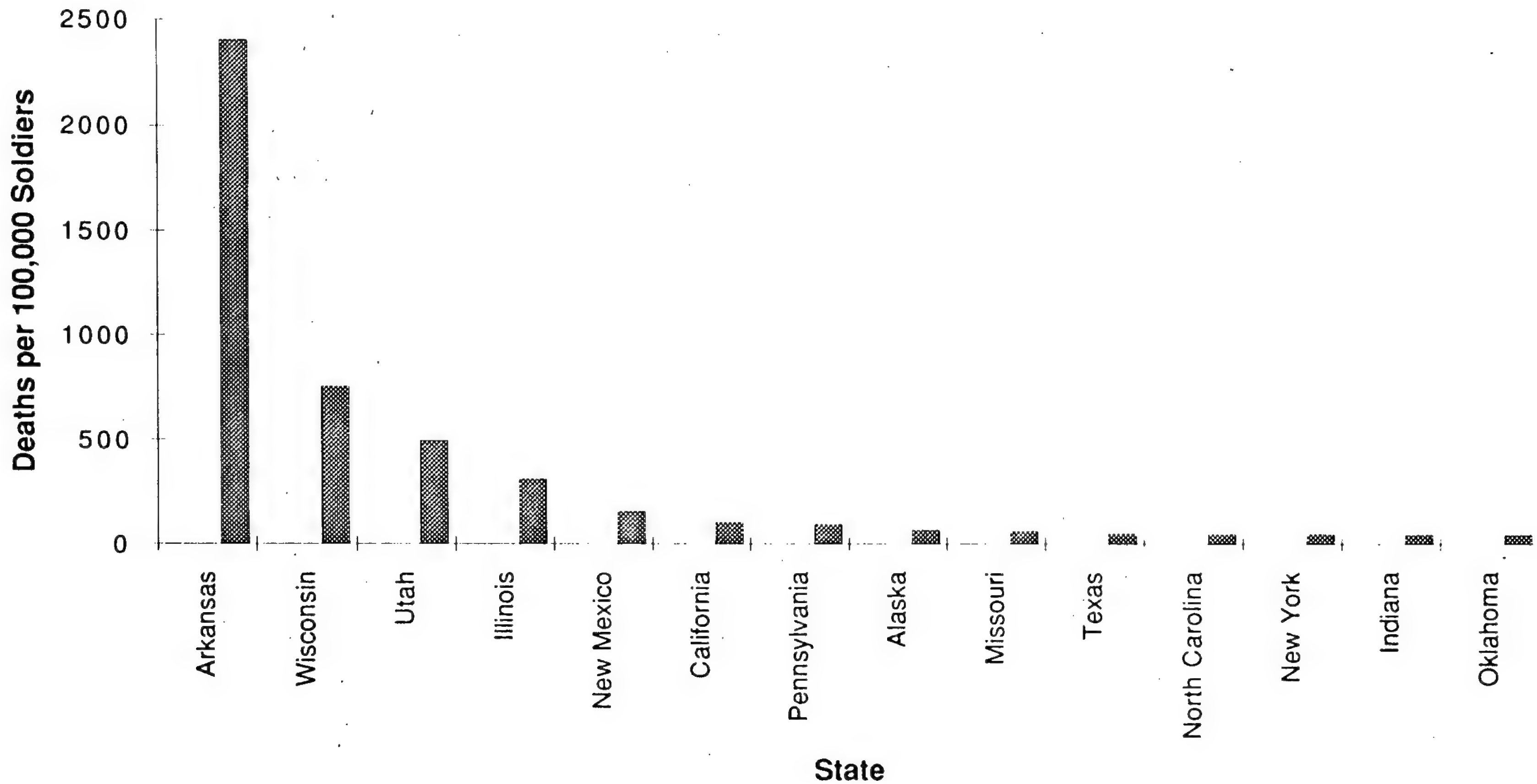


Figure 2 Average U.S. Army Unintentional Injury Death Rates by State for States with Rates Significantly Lower than the U.S. Average, 1993-1995

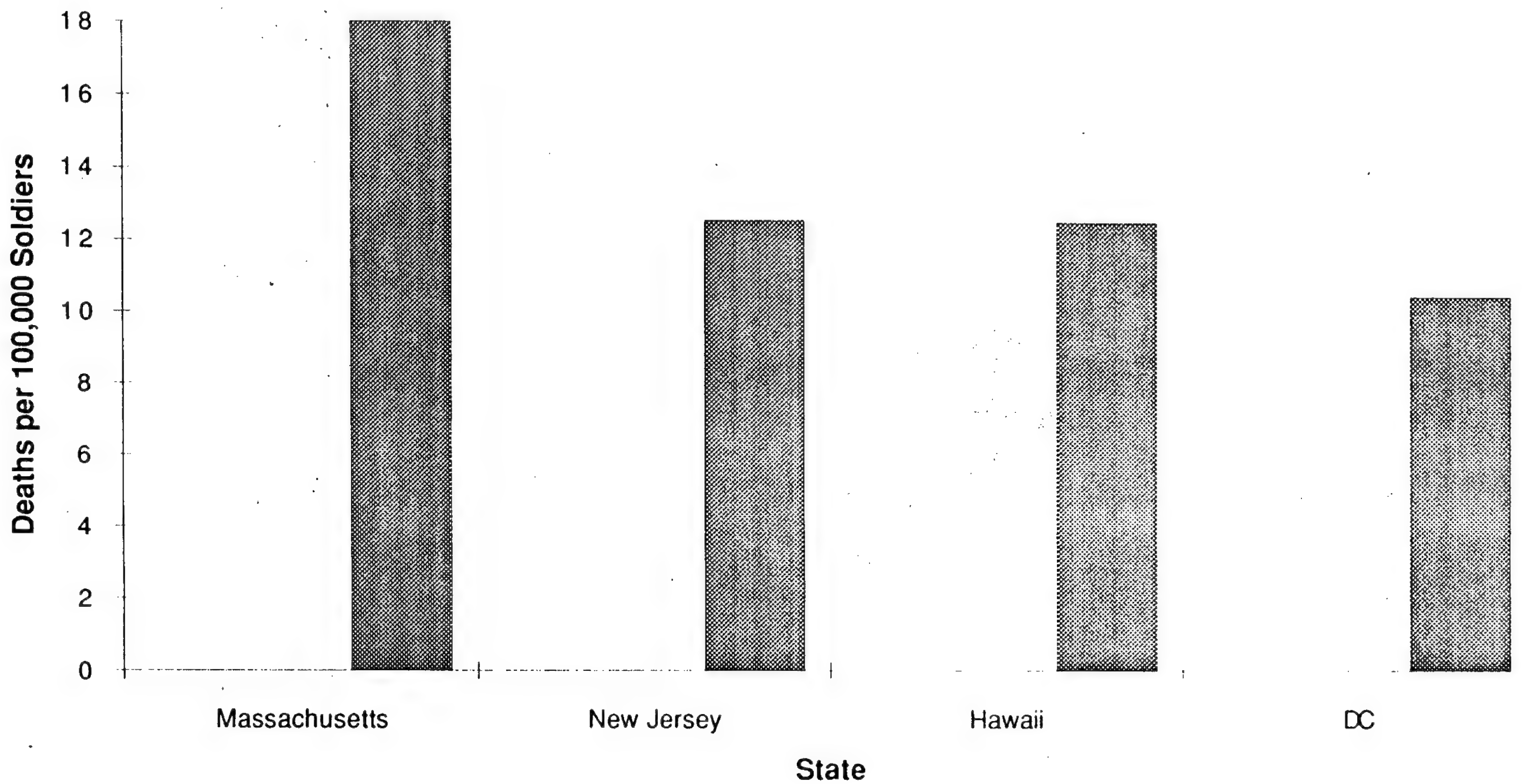
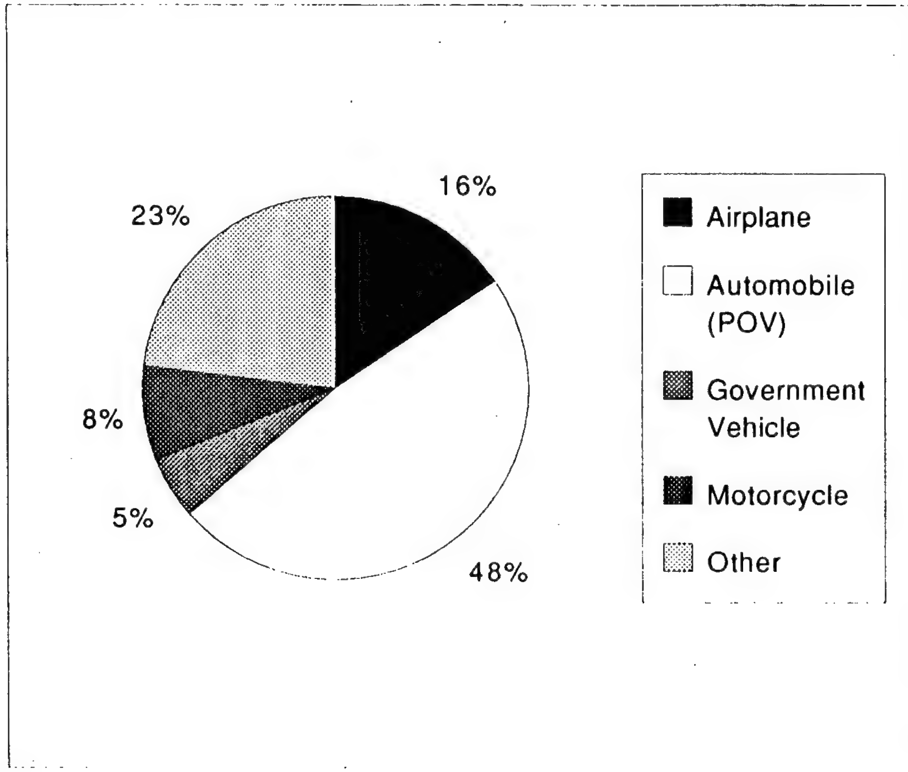


Table III and Figure 3: U.S. Army Unintentional Injury Deaths by Cause, 1994

Cause of Injury	Deaths	Deaths (%)
Airplane	26	16
Alcohol or Drugs	2	1
Asphyxiation	1	1
Automobile (POV)	79	48
Crushing/Trauma	5	3
Drowning	3	2
Electrocution	1	1
Explosion	1	1
Fall/Jump	4	2
Fire/Burns	3	2
Government Vehicle	9	5
Gunshot	4	2
Helicopter	4	2
Motorcycle	13	8
Other	2	1
Parachute	1	1
Self Inflicted	5	3
Training Exercise	2	1
Total	165	100



Abstract

A Personnel System Administrative Database Analysis of U.S. Air Force Mortality Data Using the STANAG Code

Copley GB.

Using records from the Directorate for Information, Operations and Reports (DIOR), free-text cause and circumstances information were coded into STANAG external cause codes for those deaths attributable to injury. STANAG is analogous to the ICD external cause of injury coding scheme.

The STANAG's classification scheme, however, is more pertinent to military-unique circumstances than is the ICD scheme. STANAG is used by the military of all countries under the North Atlantic Treaty Organization (NATO) umbrella.

The STANAG codes were used to analyze the 1996 United States Air Force (USAF) mortality records. From this analysis a descriptive assessment of injury mortality in the USAF using a personnel system administrative database was completed to fulfill an academic requirement. These analyses are a prototype for a more inclusive mortality study to be done within a doctoral thesis manuscript.

Appendix D

Hospitalization due to injuries in the Military: Evaluation of current data and recommendations on its use for injury prevention

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Abstract

Introduction. The largest health impact on military populations in terms of hospitalization is injuries. Hospitalized injuries also result in the largest direct costs of medical care. Being the most serious of the nonfatal injuries, they also result in the most lost work days, include the largest proportion of disabling injuries and have the largest impact on troop readiness. The value for injury and medical surveillance has only recently been realized. The question now becomes how can injury data can be used to reduce the burden of injuries. This article examines the value of administrative hospital discharge databases in the military for routine injury surveillance, as well as investigation of specific injury problems.

Methods. Prior to 1989, each service had created independent hospital discharge systems. Since 1989 a Standard Inpatient Data Record (SIDR) was created to ensure uniformity in data collection across the services utilizing standard ICD-9 codes and NATO injury codes. Data were analyzed on both nature and cause of injury. Denominator data on troop strength was obtained from the Defense Manpower Data Center (DMDC).

Results. Hospital records data indicate that injuries and musculoskeletal conditions have a bigger impact on readiness than any other ICD-9 Principle Diagnostic Group (higher incidence, higher non-effective rate). Hospitalization rates for injury appear to be declining for all services (1980-1992). Military hospital discharge databases are an important source of information on severe injuries and are more comprehensive than civilian databases.

Conclusion. Hospital discharge data that include detailed injury information can be useful for injury prevention and surveillance purposes. The first step is to identify specific high-risk groups or hazards for targeting prevention resources. These may vary widely by service, by rank and by job tasks. Hospital discharge data can also be used to evaluate the effectiveness of interventions for reducing injury rates. Recommendations were submitted to further improve data collection for research.

Key Words. Hospitalized injuries, military hospital discharge databases, military hospitalization rates, routine injury surveillance, ICD-9 codes, troop strength

Appendix E

SPORTS AND PHYSICAL TRAINING INJURY HOSPITALIZATIONS IN THE ARMY

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Abstract

Introduction: Injuries are an important public health problem in both civilian and military populations. An area in which a substantial number of injuries can occur and yet is not often investigated in a military population, is sports activities.

Methods: A database of all hospital admissions for army personnel between 1989-1994 was used to study injuries resulting from sports and army physical training in an active duty army population. Special military cause of injury codes (STANAG) were used to identify sports injuries.

Results: For the 6 year time period, there were 13,861 admissions with an external cause of injury from sports or army physical training. Males made up 94% (n=13,020) and females 6% (n=841) of these admissions. The rates of sports injuries were 38 and 18 per 10,000 person years in males and females, respectively. Sports injuries accounted for an average of 29,435 lost duty days each year. Males lost an average of 13 ± 36 days per injury and females 11 ± 30 days per injury. Acute musculoskeletal injuries in the categories of fractures, sprains/strains, and dislocations made up 82% of all injuries. The knee was the most often injured body area in both sexes with the anterior cruciate ligament being the most frequent injury overall. The top seven injuries were virtually identical for the two sexes, with only slight variations in order. Although the rates of all hospitalized sports injuries were higher in males than females, women had a higher proportion of anterior cruciate ligament injuries in basketball and softball, ankle fractures in softball, and head injuries in basketball. In males, football and basketball contributed to the highest rates of injuries. The highest injury rates in females were from army

physical training and basketball. In both sexes, army physical training was the leading activity causing lumbosacral strains.

Conclusion: In conclusion, sports and army physical training are an important source of injuries that result in a significant amount of lost duty time and readiness.

Keywords: Injury, Sports, Military, Army

Introduction

Injuries are an important public health problem in both civilian and military populations. The time away from work and the financial repercussions of injuries are now well recognized.[1] The Armed Forces spend a great deal of time and energy investigating their military training techniques and work environments to evaluate effectiveness, ensure safety in the training and work environment, and reduce injuries resulting in lost duty time. Musculoskeletal injuries are a frequent occurrence in all military branches, usually occurring more often in combat units due to the nature of the physical activity performed.[2] At a large army facility, Tomlinson, Lednar, and Jackson[2] found an overall acute injury rate of 81 injuries/100 soldiers/year, with a rate of 85 for males and 40 for females. Their sample size was relatively small and data was collected over a short period of time (two, one-week samples of active duty soldiers reporting to 4 different troop medical clinics). Fractures, sprains and dislocations made up 53% of all injuries. Similar injury patterns were seen in a sample of 298 male infantry soldiers, but cause of injury was not reported.[3]

Although training and occupational injuries are of major importance, another area which is often overlooked and in which a substantial number of injuries occur, is sports. The large majority of the literature on sports injuries has examined civilian populations. Active duty military personnel, like their civilian counterparts, participate in a significant amount of sports, both on and off duty, and yet injuries occurring as a result of this athletic participation have not been closely studied. Depending on their location and duty station, soldiers may have a very demanding schedule, or find themselves with a great deal of free time in which they can participate in sports on a recreational or competitive

basis. Injuries occurring as a result of participation in sports can lead to prolonged time away from a soldier's primary duty requirements and deployment status. Understanding the extent of injuries due to sports is therefore important to the mission of the Army. A study in the British Services between 1969-1980 found the rates of injury from sports to be 6.5/1000 person years.[4] Tomlinson, Lednar, and Jackson's study[2] mentioned above, found that 38% of all injuries occurred in the gym or athletic field and that 80% of all injuries occurring between 0500-0800 were associated with exercise/sports. Recreation activities have been shown to comprise 19% of all injuries occurring on the flight deck, hangar bay, or gym of a US Navy Aircraft Carrier and 25% of injuries resulting in lost duty time.[5]

Little is known about sports injuries resulting in hospitalization. As part of an ongoing study of injuries in the military, this study looked at all hospitalizations due to sports and physical training in the army between 1989-1994 to determine the impact that such injuries have on the readiness of the army. The characteristics of injuries occurring from sports and physical training, the association between individual sports and specific injuries, and the differences between men and women regarding the impact and pattern of sports injuries resulting in hospitalization was also investigated.

METHODS

In 1994, a Tri-service Review Panel approved funding for the U.S. Army Research Institute of Environmental Medicine (USARIEM) for studying the impact of injuries on the health and readiness of women in the Army from 1980-1994. As part of this initiative, a large database combining existing personnel, hospitalization, and medical outcomes data from various Army and Department of Defense (DoD) sources was designed into a single relational database. The resulting database, was called The Total Army Injury and Health Outcomes Database (TAIHOD).[6] Hospitalization data from the TAIHOD between January 1, 1989 and December 31, 1994 was evaluated. Instead of the International Classification of Disease external cause of injury codes (E-codes), the army uses the NATO/STANAG (Standardization Agreement) 2050 coding system for recording external causes of injury. The STANAG system uses a 3 digit code to classify the activity at the time of injury, the intent, and location. A unique feature of the STANAG system is that sports injuries are identified separately, unlike ICD-9 E-codes. All U.S. Army active duty personnel hospitalized with codes 200-249 (hospitalization due to athletics and sports, including army physical training) were evaluated. Data was recorded for 17 sports, 1 physical training (PT) category, and 1 "other" category, which consists of all sporting activities not specified in the 18 other codes, e.g. running and volleyball. Discharge diagnoses were coded according to the Classification of Disease 9th Revision, Clinical Modification (ICD-9-CM).

To determine what body parts are most frequently injured with sports/training participation, all primary diagnosis codes were divided into the different body areas sustaining the injury. In an attempt to determine what injuries were directly caused as a

result of the soldier's participation in the listed sport, only those admissions with a primary diagnosis of an acute musculoskeletal or traumatic injury as well as those soft tissue injuries resulting from recent cumulative trauma were included. Any primary admission diagnoses coded as an old injury, e.g. old anterior cruciate ligament (ACL) tear, or as a chronic musculoskeletal condition, e.g. degenerative disc disease, were not included in the determination of body areas affected. In addition, conditions without a distinct body area such as internal organ injuries, superficial wounds, psychological disorders, allergies, etc. were not included.

The Statistical Software SPSS 6.1 was utilized for all statistical analysis. Year-end denominator data for 1989-1994, to determine prevalence rates, (army-wide, gender, racial, and grade-specific population data) was obtained from TAIHOD technical report T97-10.[7]

RESULTS

Demographics: Of the 120,430 hospital admissions with an external cause of injury recorded, 11% (n=13,861) had injuries sustained from sports or PT (codes 200-249). Males made up 94% (n=13,020) of the admissions from sports and PT, and females 6% (n=841).

The age range of those admitted for injuries from sports and PT was 17 to 65 years. Forty percent of the population was between ages 20-24. Just over half (50.5%) of all admissions were single, never-married soldiers. The Grade (rank) of all admissions was distributed as follows: 79% enlisted, 11% cadets, 9% officers, 1% warrant officers (W).

Overall, the rate of sports injuries was twice as high for males as females. White females and black males had higher injury rates than other races of the same sex. Enlisted grades E1-E4 had the highest sports injury rates at 37.5/10,000 person years (**table 1**).

Sports Activities: Ten activities are team sports and 8 are individual activities. Basketball and football had the highest rates of injuries overall and in males. In females, PT and basketball had the highest rates of injury (**table 2**).

Injury Characteristics: The body parts injured was classified for 81% (n=11,280) with only 2,581 (19%) admissions not being able to be classified as described in the methods section. The knee was the most frequently injured body part in both sexes, followed by the ankle (**figure 1**). In males, basketball and football caused the most injuries to 16 out of 18 of the body parts, while softball and PT caused the most injuries to 11 out of 18 body parts in females.

Four ICD-9 categories made up 83%(n=11,433) of all admissions: fracture codes 800-829 (33%), sprain/strain codes 840-849 (29%), dislocation codes 830-839 (15%) and intracranial injuries, codes 850-859 (5%). The rates of injuries within each of these categories varies with each sport and with sex (**table 3**).

The seven leading injuries were the same for both sexes, with similar but not identical rankings (**table 4**). The most frequent causes of these injuries are illustrated (**table 5**). The anterior cruciate ligament (ACL) was the most frequent injury in both sexes. The rates of all injuries, including the ACL, were higher in males than in females. In males, basketball and football clearly predominate as the 2 sports causing the majority of the top 3 injuries within all 4 diagnostic categories. In females, softball was the most frequent cause of the top 3 fractures and of concussions, whereas basketball again led in

causing the majority of the remaining most frequent injuries. Within the sports that caused the most injuries, women had a greater proportion of ACL injuries than men in both basketball (18% versus 11%) and softball (11% versus 7%) **(figure 2)**. In basketball, females had a higher proportion of head injuries than men (10% versus 3%). In softball, ankle fractures occurred more frequently in females than in males (18% versus 12%).

Although not one of the causes of the top 3 injuries represented in table 5, PT had one of the highest overall rates of injury in women **(table 2)**. There were some clear gender differences in injuries incurred from PT. Women had a greater proportion of lumbosacral strains (9% versus 5% in men), whereas, men had a greater proportion of ankle sprains than women (11% versus 4%) from PT. Overall, PT was the most common cause of lumbosacral strain in both sexes.

Lost Duty Time: Lost duty time, the total number of days in which a soldier is not able to do his regular duty, can be estimated from the hospital data. It is composed of the combination of days spent in the hospital, on convalescent leave (vacation days given to the soldier for recuperation), and in a medical holding company (a unit which is on the rolls of the hospital to which soldiers are assigned when well enough to leave a hospital bed but not well enough to be sent back to their regular unit). Lost duty time, as determined from the hospital data, is an estimate, as is does not account for any additional days off given to the soldier at outpatient followup or due to complications. For all sports combined, there was a total of 176,609 lost duty days over the 6 year period for an average of 29,435 days lost per year. Males accounted for 167,466 lost duty days and females 9,143 days. Despite the fact that football, basketball, softball, and PT were some of the most frequent injury causing activities, they were not the activities causing

the most lost duty time per injury (**table 6**). Males lost an average of 13 days per injury and females 11 days per injury. Track and field had the highest average lost duty days per injury for both sexes. Seventy-two percent of the injuries occurring in track and field were musculoskeletal, with ankle sprains and meniscal injuries being the most common. Excluding cricket, rugger, and hockey, (all had an n<10 in females and median of lost duty days <2 in males) the sport demonstrating the largest median of lost duty days for females was handball . In males, no single sport predominated (**table 6**). Analysis of the 16 injuries incurred from handball in females revealed: 6 injuries to the anterior cruciate ligament, 2 ankle sprains, 2 open wounds to the knee, leg, or ankle, 1 venous thrombosis, and miscellaneous sprains/strains and fractures. No eye injuries occurred from handball in females, whereas, 22% of all handball injuries in males were to the eye.

Disposition: Of the 13,861 admissions in the 6 year period, 13,142 (95%) returned to duty, 564 (4%) were transferred to another facility, 130 (0.9%) were separated from the army at the time of hospital discharge, and 18 had an unknown disposition. In addition, there were 7 deaths that resulted from a sports injury which occurred during hospitalization. It is unknown how many deaths occurred outside of the hospital. The 7 deaths all occurred in males. The activities responsible for these deaths were: mountaineering/skiing/rockclimbing (2), swimming (2), "other"(2), and boating (1).

DISCUSSION:

To our knowledge, the data presented above is one of the first descriptions of sports injury hospitalizations in an U.S. Army population. A recent report looking at the 25 largest U.S. Army Military Occupational Specialties (MOS) identified that athletics and sports are an important cause of injuries being the third largest cause for men (16%) and fifth for women (9%).[8] It is clear from our data that sports and PT injuries account for a large number of lost duty days per year.

Findings of special interest include the differences between males and females. With the rise in participation of women in male roles has come a body of literature addressing the differences between men and women.[9-28] Women now make up 14% of the active duty personnel in the Armed Forces and occupations are opened up that have traditionally been barred to females.[29] Women more than ever are working in nontraditional roles and are participating in male-dominated sports. Since this equality in roles has increased, emphasis has been placed on determining gender differences in health and illness behavior. A study looking at hospitalization rates in Navy Enlisted Personnel between 1973-1975 found that women had 1.7-3.2 times higher hospitalization rates than men across pay grades E5-9 to E2 respectively. Over one third of the hospitalizations in women related to pregnancy-related conditions. When comparing men and women in traditional versus nontraditional jobs, differences were minimal, although rates for nontraditional personnel of both genders were somewhat higher than those assigned to traditional jobs.[9] Bishop[10] compared women and men in the army in both administrative and combat units. He found that although interviewed women reported having health problems in the last year twice as often as males, there were no gender

differences in the rate of symptoms or in their behavioral responses to symptoms reported in their health diary . The rate of symptoms reported in the combat units was twice as high as that in the administrative units for both males and females. Without respect to work unit, the rate of hospitalization for sports-related injuries in our population was twice as high for males as females.

The literature has shown repeatedly that females have a higher rate of injuries and lost duty time during basic training than their male counterparts.[11-17] Feuerstein, Berkowitz, and Peck[18] looked at disability rates in US Army personnel and found that musculoskeletal disorders made up 51% of all disability cases, with women experiencing higher rates overall and of musculoskeletal disability than men performing the same jobs.

When looking specifically at sports activities in civilians, there is again a large body of evidence that injuries occur more frequently in females.[19-28] The National Collegiate Athletics Association (NCAA) recorded knee injury rates between 1989 and 1993 and correlated the injuries with the activities causing them. Knee injury rates were higher in women than men in comparable activities. Of the activities comparable to men, the sports most likely to be associated with the highest specific knee injury rate was: gymnastics, ACL (0.52/1000 athletic exposures in females versus 0.17 males); soccer, collateral ligament (0.57 females, 0.56 males); basketball, collateral ligament (0.27 females, 0.18 males); lacrosse, patellar tendon (0.22 females, 0.15 males). Of the sports not comparable to men, field hockey had the highest injury rate at 0.78, followed by volleyball and softball.[19] In women's intramural flag football, injury to the finger was the most frequent at 39% followed by the knee at 16% and ankle at 8% of the injuries. Sprains/strains and fractures made up 65% of all injuries.[20] A study comparing one men's

and one women's professional basketball team found that women had 60% more injuries than did men, with the ankle being the most frequent body part injured in both sexes.[21] With collegiate level basketball and soccer, the NCAA data found that for female soccer players, the ACL injury rate was 3 times the rate for males, and in basketball, 2 times. The overall injury rate was 2.4 times higher for female soccer players and 4.1 times higher for female basketball players than their male counterparts.[22,23] Others have reported similar results.[24,25] Of interest is that women are more likely to sustain noncontact injuries, especially to the ACL, and are more vulnerable to overuse syndromes. Males are more likely to sustain injuries by contact mechanisms.[19,25] Although the reason for these differences in knee injuries is not clear, they have been attributed to anatomic, physiologic, and conditioning differences.[19,26-28]

The patterns of injury observed with our investigation of sports injuries in active duty army personnel were similar to that reported in the literature. The rates of hospitalization of all acute musculoskeletal injuries due to sports injuries was higher in males than in females. The anterior cruciate ligament was the most frequent knee injury overall in both sexes, with the rate of injury higher in males than in females. This is different than expected, based on the literature; however, our results, unlike most studies in the literature, looked at sports injuries severe enough to require hospitalization. The proportion of ACL injuries in basketball and softball, however, was higher for women than for men.

There were other findings unique to our population. The frequency and rate of injuries incurred as a result of PT was higher in females than in males. This is of particular importance as PT is the only activity for which we can assume similar

exposure. PT was a frequent cause of injury hospitalization (first in women and fifth in men). Tointon[4] also found PT to be an important cause of injury and medical discharge in the British Service. Handball was the sport causing the largest median of lost duty days in females, and closer evaluation of injuries within this sport led to some interesting findings. No eye injuries were recorded in female handball hospitalizations, whereas in males, they made up 22% of all handball injuries. Protective eyewear is required when playing racquet-sports in a military facility. Whether these injuries occurred while playing at a non-military facility or whether males were non-compliant with the use of the eyewear once the equipment was checked out, is not known.

The importance of understanding the epidemiology of sports injuries and the principles of effective interventions in sports has increasingly been recognized.[30] The limitations of epidemiologic studies of sports injury are many. As in all epidemiologic studies looking at rates of athletic injuries, determination of rates and meaningful comparisons can be compromised because of varying exposure of participants to the risk of injury (i.e. denominator data), different definitions for the term "injury", and the data sources used to record sports injuries. A major limitation of our study is the lack of exposure data of participants for each of the activities. Although we have determined rates from the population census, our data may have given a very different picture had we been able to calculate rates based on the amount of exposure that each sex had to the activity. This makes accurate comparison with other studies in the literature difficult. The one possible exception to this limitation is PT, an activity in which all active duty personnel participate for a minimum of 1 hour per day 3 times a week. This varies widely among military units and especially between officers and enlisted personnel. The

important point however, is that exposure should be similar between males and females, unlike many of the other activities. While the lack of exposure data is a limitation, a strength of this study is the fact that we were able to look at all sports in an army population, and determine the impact of sports injuries on readiness. With the exception of the study by Tointon[4] this study is one of the first to look at sport injuries in a broad cross-sectional way.

Another limitation of this study is the lack of a uniform severity scale. One could assume that because all of the injuries reported were hospital admissions that the injuries are rather severe. In a military setting, however, this may not always be the case. Often times, an unmarried soldier living in the barracks may be hospitalized due to environmental barriers (e.g. stairs) or the absence of a caretaker in the outpatient setting, even though the injury may not be severe. In the active duty population studied, 50% of soldiers were unmarried. At the other extreme, rather severe injuries in a group of soldiers with a high threshold for reporting injuries (e.g. special forces and rangers) may be underrepresented, as they may be self-treating or treated in an outpatient setting and not be hospitalized. Both extremes have potential to bias the database.

Finally, the referral source for injuries has most likely changed over the 6 year period, whereas the data collection source has not. The highest rate of sports and training injuries occurred in 1991 and 1992 at 43.5 and 39.0/10,000 person years respectively. The meaning of this data is questionable. It may reflect injuries during Desert Storm, however, it is likely that the gradual decline after 1992 reflects the trend toward outpatient treatment. Such a trend has occurred to a great extent in both the military and civilian setting. If these figures do reflect a trend toward outpatient treatment, the impact

of injuries from sporting activities on morbidity and lost duty time may be significantly underestimated in our data.

Suggestions for future work are to continue to make improvements in the available databases. Despite the unclear etiology of the category listed as "other", it is clear that the total number of injuries from sporting activities other than those specifically listed makes up a substantial number of injuries (15%). This ill-defined group had the third highest injury rate at 14.6/10,000 person years. The "other" category represents a number of different activities such as running, biking, volleyball, etc. Given the large number of injuries coded within this category, it may be beneficial to investigate whether activities within this category could be defined into useful, more descriptive causes. Given the size of the army and the worldwide distribution of soldiers, collecting injury data with the appropriate exposure denominator data will be challenging. On the other hand, all branches of the Armed Forces have very sophisticated computer capability and with a great deal of time and effort, a similar outpatient database with exposure data recorded, on at least a company level, would be possible to develop. Given military cutbacks and the essential need of all branches of the service to keep their personnel in optimal condition, such an endeavor is worth pursuing.

In conclusion, sports and army physical training account for a large number of lost duty days per year in both sexes. Males and females had similar but not identical injury patterns. The increased proportion of ACL injuries in women compared to men in basketball confirms the findings of others. The higher rate of PT injuries, and the greater proportion of head injuries in basketball and ankle fractures in softball in females compared to men, is of interest and requires further investigation to identify preventative

measures. The fact that 22% of handball injuries in men were to the eye suggests that more stringent enforcement of protective eyewear is needed.

Table 1: Demographics of Persons Hospitalized for Sports Injuries in the U.S. Army 1989-1994

VARIABLE	STRATA	FREQUENCY	(%)	POPULATION	INJURY RATE PER 10,000 PERSON YEARS
Sex	Male	13020	94.0	3,406,093	**38.2**
	Female	841	6.0	460,567	18.3
Age (years)	<20	1801	13.0	*	*
	20-24	5627	40.6		
	25-29	2981	21.5		
	30-34	1804	13.0		
	35-39	1038	7.5		
	>39	597	4.3		
Race	White M	8379	64.4	2,195,216	38.2
	F	562	66.8	219,110	**25.6**
	Black M	4160	32.0	893,473	**46.6**
	F	257	30.6	202,810	12.7
	Asian M	64	0.5	61,173	10.5
	F	8	1.0	9079	8.8
	Indian M	7	0.1	17,305	4.0
	F	0	0.0	3505	--
	Other M	410	3.1	238,926	17.2
	F	14	1.6	26,063	5.4
Military Rank	Cadets	1544	11.1		
	E1-E4	6753	48.7	1,802,196	**37.5**
	E5-E7	3976	28.7	1,389,046	28.6
	E8-E9	168	1.2	99,093	17.0
	O1-O3	925	6.7	305,622	30.3
	O4-O6	341	2.5	183,996	18.5
	O7-O11	2	.0	2243	8.9
	W1-W5	179	1.3	84,268	21.2
Year	1989	2008	14.5	758,207	26.5
	1990	2751	19.8	735,386	37.4
	1991	2987	21.5	686,950	**43.5**
	1992	2326	16.8	596,663	39.0
	1993	2029	14.6	560,764	36.2
	1994	1760	12.7	528,690	33.3

***There is no denominator data available for each age group. Rates in bold represent the highest rate within each category/strata**

Table 2: Sporting activity frequencies and hospitalized injury rates

	OVERALL			MALE			FEMALE		
Sporting Activity	**Frequency**	**%**	**Rate***	**Frequency**	**%**	**Rate**	**Frequency**	**%**	**Rate**
Basketball	3208	23.1	**8.29**	3082	23.7	**9.05**	126	15.0	**2.70**
Football	3041	21.9	**7.86**	2994	23.0	**8.79**	47	5.6	1.00
Softball	1151	8.3	2.98	1061	8.1	3.12	90	10.7	2.00
PT	840	6.1	2.17	711	5.5	2.09	129	23.4	**2.80**
Soccer	792	5.7	2.05	757	5.8	2.22	35	4.2	0.76
Wrestling	594	4.3	1.54	561	4.3	1.65	33	3.9	0.72
Mtn/Ski/Rk	563	4.1	1.46	493	3.8	1.45	70	8.3	1.50
Baseball	455	3.3	1.18	427	3.3	1.25	28	3.3	0.61
Boxing	243	1.8	0.63	243	1.9	0.71	0	0.0	0.00
Swimming	228	1.6	0.59	208	1.6	0.61	20	2.4	0.43
Handball	207	1.5	0.54	191	1.5	0.56	16	1.9	0.35
Rugger	176	1.3	0.46	174	1.3	0.51	2	0.2	0.04
Horsemanship	107	0.8	0.28	82	0.6	0.24	25	3.0	0.54
Track & Field	68	0.5	0.18	57	0.4	0.17	11	1.3	0.24
Tennis	67	0.5	0.17	61	0.5	0.18	6	0.7	0.13
Hockey	52	0.4	0.13	49	0.4	0.14	3	0.4	0.07
Boating	31	0.2	0.08	29	0.2	0.09	2	0.2	0.04
Cricket	14	0.1	0.04	13	0.1	0.04	1	0.1	0.02
+Other	2024	14.6	5.32	1827	14.0	5.36	197	23.4	4.30
Total	**13861**	**100**	**35.8**	**13020**	**100**	**38.2**	**841**	**100**	**18.3**

***All rates are per 10,000 person years. The rates in bold represent the top 2 highest rates for that category.**
+ "Other" category consists of all sporting activities not specified e.g. running, volleyball, etc.

Table 3: Rates of injury hospitalization within the 4 most frequent injury categories by sport and gender

Fractures	Rate*		Sprains	Rate*		Dislocation	Rate*		Intracranial	Rate*	
	M	F		M	F		M	F		M	F
Football	**3.47**	0.43	Basketball	**3.81**	**1.10**	Basketball	**1.60**	**0.50**	Football	**0.58**	0.02
Basketball	2.32	0.46	Football	2.32	0.41	Football	1.08	0.07	Boxing	0.28	----
Softball	1.51	**0.98**	PT	0.72	**1.10**	Softball	0.47	0.17	Basketball	0.25	**0.26**
Soccer	0.94	0.33	Softball	0.54	0.43	PT	0.37	0.43	Softball	0.14	0.24
Baseball	0.65	0.19	Soccer	0.50	0.22	Soccer	0.33	0.11	Wrestling	0.14	0.11
Mtn/ski/rk	0.62	0.41	Mtn/ski/rk	0.43	0.61	Wrestling	0.28	0.04	Soccer	0.12	----
Wrestling	0.54	0.26	Wrestling	0.38	0.13	Mtn/ski/rk	0.16	0.35	Baseball	0.07	0.04
PT	0.37	0.37	Baseball	0.22	0.24	Baseball	0.15	0.07	Rugger	0.07	----
Swimming	0.24	0.13	Handball	0.17	0.17	Handball	0.07	0.04	Mtn/ski/rk	0.06	0.07
Boxing	0.16	----	Rugger	0.14	----	Swimming	0.06	0.02	Swimming	0.04	0.07
Rugger	0.14	0.04	Boxing	0.07	----	Boxing	0.06	----	PT	0.03	0.07
Horseman	0.11	0.28	Track	0.06	0.09	Track	0.04	0.02	Horseman	0.03	0.04
Handball	0.11	0.04	Tennis	0.06	----	Rugger	0.03	----	Handball	0.02	0.02
Tennis	0.04	0.04	Swimming	0.05	0.07	Horseman	0.02	0.07	Hockey	0.02	0.02
Hockey	0.03	0.02	Hockey	0.05	----	Tennis	0.02	0.04	Tennis	0.01	0.02
Track	0.03	0.04	Horseman	0.02	0.02	Hockey	0.01	----	Track	0.00	----
Boating	0.02	----	Boating	0.01	0.04	Boating	0.01	----	Boating	----	----
Cricket	0.02	----	Cricket	0.01	----	Cricket	0.01	----	Cricket	0.00	----
Other	1.45	0.98	Other	1.53	1.50	Other	0.93	0.50	Other	0.18	0.20

***All rates are per 10,000 person years. The rates in bold represent highest rate within each category. Abbreviations: M = male; F= female**

Table 4. Top ten admitting diagnoses for injuries sustained during any sporting activity

OVERALL	N=	%	MALES	N=	%	RATE	FEMALES	N=	%	RATE
Anterior Cruciate Ligament	1289	9.3	Anterior Cruciate Ligament	1181	9.1	**3.47**	Anterior Cruciate Ligament	108	12.8	**2.34**
Meniscus Tear	1261	9.1	Meniscus Tear	1177	9.0	3.46	Meniscus Tear	84	10.0	1.82
Ankle Sprain including Achilles	1086	7.8	Ankle Sprain including Achilles	1033	7.9	3.03	Ankle Fx	66	7.8	1.43
Ankle Fracture (Fx)	982	7.1	Ankle Fx	916	7.0	2.69	Ankle sprain including Achilles	53	6.3	1.15
Knee sprain-all other ligaments	772	5.6	Knee sprain-all other ligaments	732	5.6	2.15	Knee sprain-all other ligaments	40	4.8	0.87
Phalynx Fx of hand	618	4.5	Phalynx Fx of hand	592	4.5	1.74	Cerebral contusion	31	3.7	0.67
Cerebral contusion	484	3.5	Cerebral contusion	453	3.5	1.33	Phalynx Fx of hand	26	3.1	0.56
Malar maxillary Fx	206	1.5	Malar/maxillary Fx	204	1.6	0.60	Lumbosacral strain	24	2.9	0.52
Distal Radius Fx	194	1.4	Distal Radius Fx	188	1.4	0.55	Neck sprain	11	1.3	0.24
Nasal Fx or Lumbosacral strain	172	1.2	Nasal Fx	162	1.2	0.48	Nasal Fx	10	1.2	0.22

Frequencies are based on the overall total n= 13861; males, n=13020; females, n=814.
Rates are per 10,000 person years. Abbreviations: Fx = fracture

Table 5: Top 3 injuries within each diagnostic category and the respective sport most commonly causing each injury. The overall rate of each injury and the rate at which each specific injury occurs in relation with the sport listed is included.

MALES				FEMALES			
Top 3 injuries	Overall Injury rate *	#1 Sport cause of Injury	Injury Rate * from Sport	Top 3 Injuries	Overall Injury rate*	#1 Sport cause of Injury	Injury Rate* from Sport
<u>Fracture</u>				<u>Fracture</u>			
1. Ankle	2.69	1.Football	0.69	1. Ankle	1.43	1.Softball	0.35
2. Phalynx of Hand	1.74	2. Football	0.65	2. Phalynx of Hand	0.56	2. Softball	0.15
3. Malar /Maxillary	0.60	3. Football	0.24	3. Tibia	0.37	3. Softball	0.09
<u>Sprain</u>				<u>Sprain</u>			
1.ACL	3.47	1.Basketball	0.96	1.ACL	2.34	1.Basketball	0.48
2. Ankle (includes achilles)	3.03	2.Basketball	1.47	2. Ankle (includes achilles)	1.15	2.Basketball	0.35
3.+Knee- other	2.15	3.Basketball	1.02	3.+Knee- other	0.87	3.Basketball	0.22
<u>Dislocation</u>				<u>Dislocation</u>			
1.Meniscus tear	3.46	1.Basketball	1.03	1.Meniscus tear	1.82	1.Basketball	0.37
2.Shoulder	0.44	2.Football	0.08	2.Patella	0.13	2.NP	
3.Hand	0.43	3.Basketball	0.17	3.Shoulder	0.11	3.Basketball	0.04
<u>Intracranial</u>				<u>Intracranial</u>			
1.Brain Contusion	1.33	1.Football	0.34	1.Brain Contusion	0.67	1.Basketball	0.24
2.Concussion	0.70	2. Football	0.23	2.Concussion	0.48	2.Softball	0.09
3. Hemorrhage	0.01	3.Basketball & Football	< 0.01	3. Hemorrhage	0.02	3. Horseman	0.02

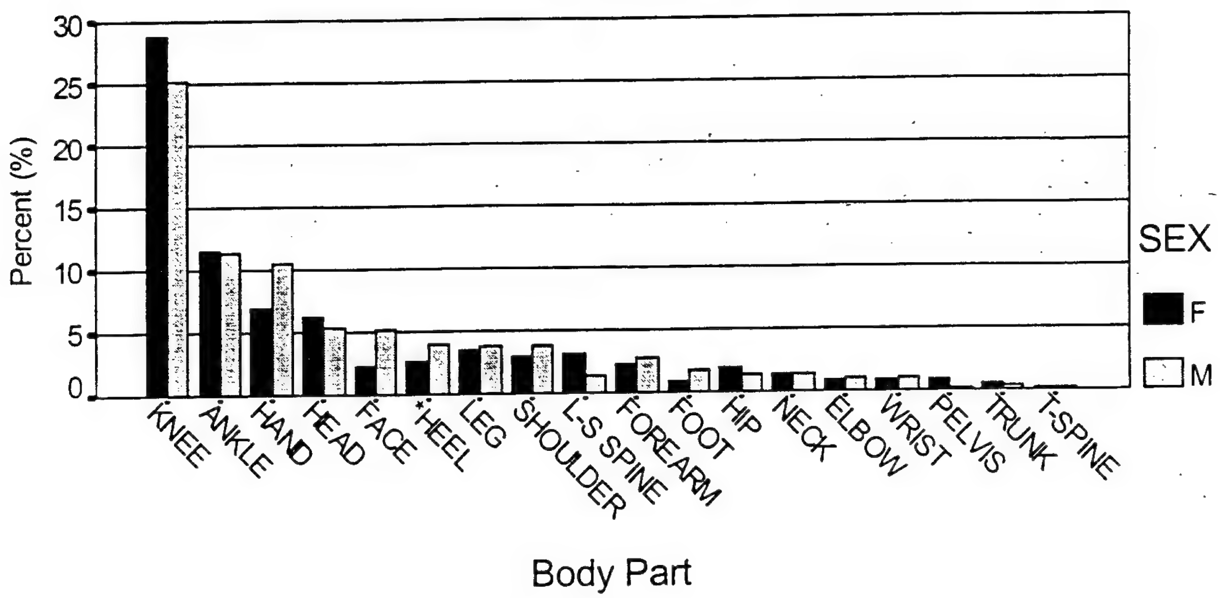
***All rates are per 10,000 person years**
+Knee-other = knee sprain of all other ligaments of the knee besides the anterior cruiciate ligament (i.e. medial/lateral collateral, tibiofibular lig., etc.)
Abbreviations: ACL = anterior cruciate ligament; NP=none predominate

Table 6: Total lost duty days for each activity by gender (median, mean, & S.D.) in descending order of mean lost duty days.

MALE							FEMALE		
Rank	Activity	Median	Mean	S.D.	Total days lost	* n=	Activity	Median	Mean
1	Track & Field	4	27	88	1519	57	Track & Field	3	32
2	Mtn/ski/rk	4	26	93	12924	493	Wrestling	4	20
3	Swimming	4	24	62	4984	208	Rugger	16	16
4	Boating	3	18	53	515	29	Soccer	4	14
5	Horseman	4	16	23	1313	82	Hockey	15	13
6	Basketball	4	13	34	41427	3082	Basketball	4	12
7	PT	3	13	36	9068	711	Other	3	11
8	Baseball	4	12	30	5183	427	PT	3	11
9	Soccer	3	12	32	9154	757	Mtn/Ski/Rk	4	10
10	Wrestling	3	12	30	6754	561	Softball	5	10
11	Other	3	12	31	22726	1827	Handball	6	9
12	Football	3	12	26	35357	2994	Cricket	8	8
13	Softball	3	11	26	11910	1061	Horseman	2	7
14	Handball	3	10	30	1899	191	Swimming	3	7
15	Tennis	3	9	15	564	61	Football	3	6
16	Cricket	2	7	12	89	13	Baseball	2	5
17	Boxing	2	5	9	1130	243	Boating	4	4
18	Rugger	2	5	9	807	174	Tennis	1	4
19	Hockey	2	3	3	143	49	--------		--
Total		3	13	36	167466	13020		3	11

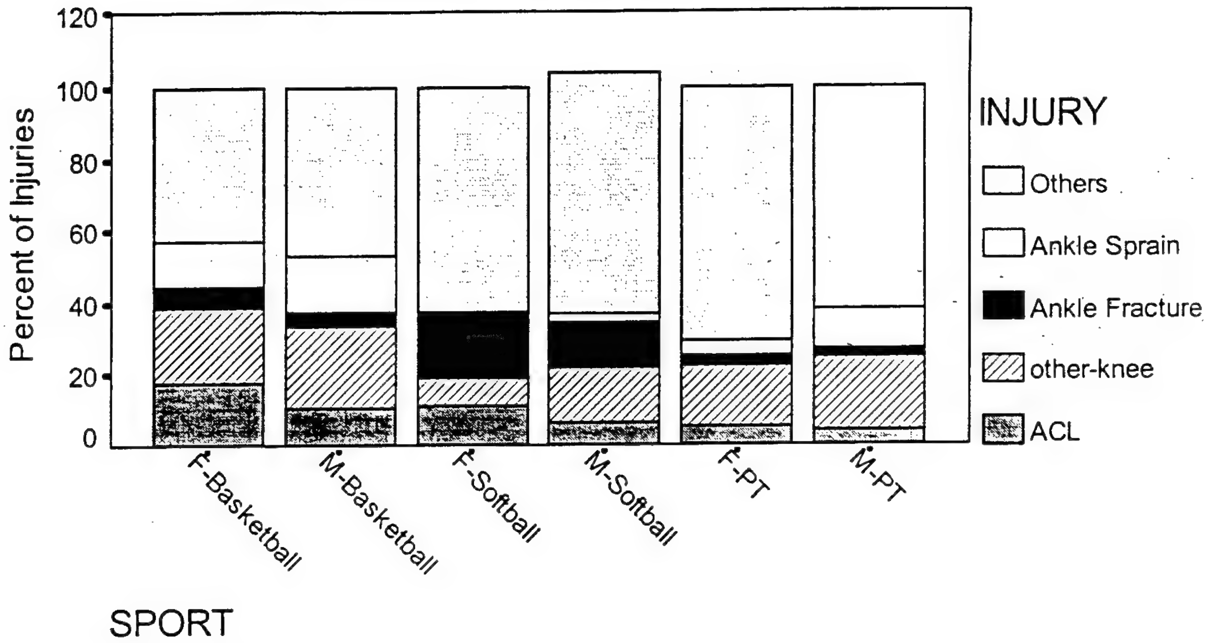
* n= number of hospital admissions for each sport

Figure 1: Percent Distribution of Body Areas Injured in Sports by Gender



*Heel = calcaneal fx, achilles tear and sprain

Figure 2: Injury Patterns by Gender



F=female; M=male

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Appendix F

The Use of Existing Military Administrative and Health Databases for Injury Research

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1 Figure, 1 Table

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A:\surveillance commentary.wpd

INTRODUCTION

This issue of the American Journal of Preventive Medicine presents a comprehensive look at the major health problem of the nation's military population – injuries. The 1.5 million members of the services, predominantly young adults, are subject to many of the same hazards that cause injuries to the civilian population in the course of work, travel, and recreation, and are of special pertinence to the study of occupational injuries.

Practitioners of occupational injury prevention have recently embarked on large-scale efforts to identify priority areas for investigation, recognize deficiencies in the data quality and methodologies that enable injuries to be prevented, implement efforts and models to permit researchers to address problems, and increase the utility of occupational injury research.[1,2] As the mechanism to identify worker groups with high frequency and risk of injury, surveillance is considered to be the driving force of research and prevention efforts.[3] Without proper attention to surveillance, priority areas based on the magnitude of the problem, risk of injury, and amenability to prevention will go unserved and limited research resources will be directed according to political considerations rather than informed strategy.

Population-based administrative databases useful for epidemiologic and outcome studies have typically included national surveys, federal health care programs, large insurance programs or health delivery care systems, statewide hospital discharge databases, and workers' compensation databases.[4] However, some of the richest sources of data, those of the armed services, have largely been left untouched. The recent creation of a relational database with the ability to link personnel records of the

total active duty Army population with various outcome measures (e.g., hospitalization, lost-time injury, physical disability, fatality)[5] may well represent the first step in the maturation of the field of occupational injury epidemiology and coincides with the outline of research needs for effective research.[3,6] This commentary describes how many of the research needs pertaining to surveillance systems have already been addressed by existing military administrative databases and suggests that these sources be better utilized for investigating the most challenging of occupational hazards.

RESEARCH TASKS ADDRESSED BY MILITARY DATA

Surveillance is "the ongoing collection, analysis, and interpretation of health data in the process of describing and monitoring a health [injury] event".[7] For the military as well as the civilian population, mortality data have been the most utilized because of their importance and availability. Injuries accounted for 81% of all deaths in the military during FY 1996.[8] Casualty data for all branches are available from the Directorate for Information Operations and Reports (DIOR) based on Department of Defense Form 1300. More information on deaths can be obtained from the casualty offices of the various services and may also be found on hard copies of Form 1300. Injury rates from DIOR, classified by intent and service (Table 1) reveal important differences among the services in the magnitude of the problem as well as in time trends. Overall injury death rates are highest for the Marines and lowest for the Air Force, with a twofold difference between these two services that may largely reflect their different missions.

Between FY 1980 and FY 1996, the trends in injury death rates for the military have been far more dramatic than for young adult civilians. Especially noteworthy are

decreases of about two thirds in unintentional death rates in the Navy and Air Force and in homicide rates in the Marines. The increases in suicide rates, especially in the Army and Air Force, have surpassed increases in the civilian world. The ability to identify such trends is one value of good surveillance data.

Recently, implementation teams for the National Occupational Research Agenda (NORA) have identified specific research capabilities required of surveillance systems, and suggestions from this report[3] will be used to demonstrate the utility of the Total Army Injury Health Outcomes Database (TAIHOD), as representative of a research database utilizing surveillance data.

Improve national-level surveillance of non-fatal injuries: TAIHOD includes more than two million hospitalization records of all Army active duty personnel between 1980 and 1997 across the nation as well as around the world. Admissions include fatal as well as non-fatal injuries and the quality of the data in terms of completeness and standardization is unusually high. Types of hospitalization data include demographics, diagnoses and procedures, DRG costs, injury type and cause (modified E-codes), and lost duty time (e.g., bed days).

Collect detailed information on the circumstances of traumatic occupational injury: For more serious events involving a loss of life or extensive property damage, the Army Safety Management Information System (ASMIS) provides detailed cause and activity data on 230,000 ground and aviation injuries involving equipment, weapon systems, and vehicles for a 18-year period (1980-1997). Event-specific information includes

descriptions of the activity (narrative), training relatedness, type and cause of injury, personal protective equipment used, drug use, environmental conditions, actions taken to eliminate the injury (narrative), and cost estimates.

<u>Utilize exposure data to calculate injury risks based on actual exposure time or exposure to risk factors</u>: The Defense Manpower Data Center (DMDC) provides an historic archive of personnel files on all active duty military personnel and permits the calculation of mid-year, end-of-year, and person-time denominators from 1979 to 1998.[9] Of particular interest are variables on demographics, hazardous duty, occupation, departure from service, and Gulf War deployment.

<u>Collect information that permits linkage to other relevant data systems</u>: Using scrambled social security numbers as case identifiers, TAIHOD data can be culled from six different data sources: personnel, hospitalization, safety, disability, casualty (death), and health risk appraisal (HRA). In particular, the HRA offers the opportunity to address behavioral aspects that are rarely available in injury epidemiology by including self-reported health habits (e.g., diet, exercise, tobacco and alcohol use, stress, risk-taking behavior, etc.).

<u>Include work-relatedness, occupation, and industry</u>: Among the hospitalization variables are those that record the circumstance of the injury (e.g., battle, assault, training, off duty, etc.). An advantage of military data is that it collects all hospitalizations, regardless of whether or not they were associated with a job task or occurred while on

duty, and whether or not in a military hospital. This may be useful for the investigation of chronic overuse conditions with undetermined etiologies and exposures that may contribute to their development from occupational, domestic, and recreational activities. Information regarding specific occupations, including task description and physical demands, are available for linkage as well.

Focus surveillance efforts on how to capture data as health care changes: The recording of outpatient surgeries (length of stay = 0 days) in the hospitalization data permits the inclusion of many conditions that are available only for civilian data by ambulatory records. However, the increasing role of outpatient services within as well as outside the military requires additional surveillance measures which are under development. Also, by maintaining TAIHOD with recent updates so that they are never more than six months behind calendar time, research questions that investigate current trends in injury, disease, and health care can be addressed.

Collaborate on surveillance efforts to meet multiple needs and decrease per-agency costs: TAIHOD uses only existing databases and therefore does not add the expense of developing a new data collection mechanism. Instead, limited funding is used to obtain, maintain, update, and query the data for specific research questions.

GENERALIZATION TO OTHER POPULATIONS

The military represents a largely young, healthy, and active population relative to the general public. Therefore, when investigations of injury interventions are found to

be effective in military personnel, the effects may be at least as effective if not more dramatic in the general population.

The military offers a unique environment to investigate the effects of interventions with a "captive" population. By its nature, research involving military personnel may permit more comprehensive evaluation than an equivalent civilian or occupational group. Examples of interventions that have been shown to be feasible among military personnel and hold promise for civilians include over-the-boot braces to prevent ankle injuries during parachute landings [10,11] and decreased amounts of exercise during basic training to reduce the risk of injury without an associated decrement in fitness.[12]

Another application of military surveillance data involved the use of hospitalization data to determine that females have a 3.9-fold greater risk of injury resulting in hospitalization than males, given the exposures associated with Army cadet basic training.[13] Hospitalization data can also be used to demonstrate how injury patterns differ between men and women in the same sport. Although exposures to most sports differ greatly for men and women, the ability to look at all of the injuries incurred in a particular sport and ask the question, "Given a hospitalized injury in this sport, what is it likely to be?" reveals interesting gender differences. For example, analysis of 1989-94 Army hospitalizations indicates that of the injuries incurred in basketball and softball, women have a greater proportion of anterior cruciate ligament injuries (18% and 11%, respectively) than men (11% and 7%) (Figure 1). In physical training, a greater proportion of men's injuries are ankle sprains – 11%, compared with 4% of women's injuries (unpublished observations).[14] Women engaged in parachuting

appear to be at significantly greater risk of lower extremity injury than men.[15] These gender differences can provide insights into injury specifics that would be pertinent to civilians engaged in similar sports. Also, Lauder's data highlighted the surprising finding that ankle fracture, an injury potentially preventable with breakaway bases,[16] represents a major proportion of injuries for both males and females while playing softball (Figure 1).

LIMITATIONS

Arguably, a major potential limitation associated with the study of military populations is limited generalizability to the civilian population. Demographic, occupational, environmental, and behavioral characteristics are likely to affect these populations in different ways.[4] In particular, differences in population ages, participation in hazardous tasks, activity level, and overall health status are likely to result in a different profile of injuries than would be representative of civilians. Information gained from the military, however, may be pertinent to civilians of similar ages or occupational exposures.

Comparability to occupational groups in civilian populations is complicated by the fact that, in contrast to a company's data for job-related injuries of its workers, medical data in the military include all injuries from falls, assaults, motor vehicles, etc. whether or not job-related. Thus, injury rates are likely to be much higher than civilian work-related injury rates. Members of the military are considered to be 'on duty' except when on leave or away without leave, but have their health outcomes recorded even when "off duty." The hospital data variable "duty status," however, may or may not correctly

identify all people with on-the-job injuries. Therefore, a person driving a private vehicle or playing basketball, for example, may be assigned a code indicating that duty status is unknown when in fact status could have been determined.

Duty status, moreover, is not a separate variable in Army hospitalization data but is combined with the 'intent' of injury; the resulting 'trauma code' includes codes for accidental injury -- off duty, schemes and exercises, other scheduled training, on duty, and unknown whether on or off duty – yet the same variable includes codes for nonbattle assaultive injury and self-inflicted injury without mention of whether on or off duty. Ideally, there should be separate codes for intent and duty status.

Data from the military safety centers are not representative of all injuries since cases chosen for investigation may underrepresent injuries that occur off base and overrepresent injuries that are serious and/or of special interest to the investigators. Also, since injuries are an undesirable occurrence, unit leaders may have a disincentive to report them. Safety center data are useful, however, because of the availability of details on how the injury occurred. Researchers can capitalize on this detailed information through the use of case-control studies or other designs that do not require information on all injured personnel.

RECOMMENDATIONS

In their landmark report to the Armed Forces Epidemiological Board, *Injuries in the Military: A Hidden Epidemic,*[17] the authors make a number of recommendations. One of the most important unmet needs at present is for an automated, service-wide outpatient data system with a minimum data set that includes age, race, gender,

diagnosis, cause and circumstances of injury. Cause of injury codes should be included in all hospitalization records, including admissions for the ICD subgroup of musculoskeletal conditions, many of which presently lack cause data. Free text in automated outpatient, inpatient, and mortality records -- including in deployment situations -- would greatly enhance the ability to identify specific circumstances of injury and develop preventive measures, which should be a major outcome of surveillance data.

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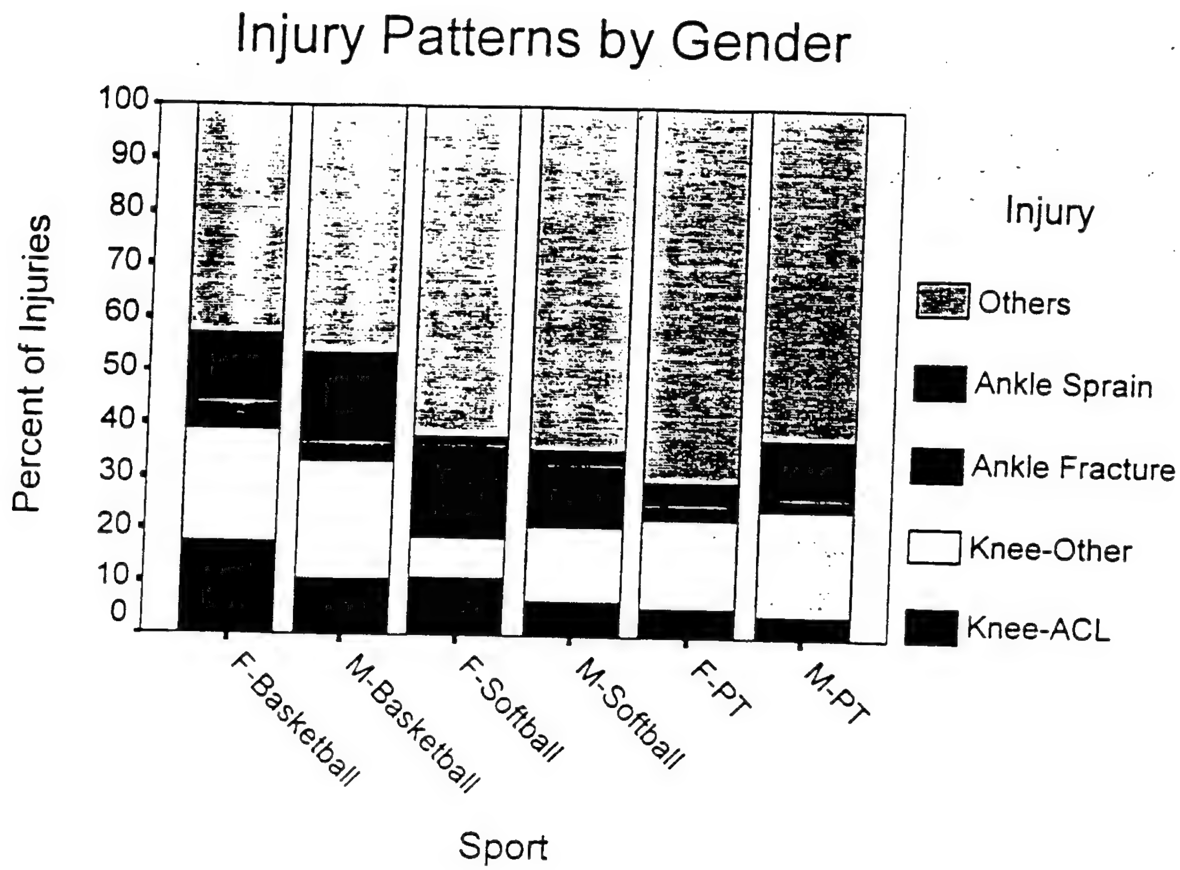
Figure 1. Injury Patterns by Gender and Sport



F=female; M=male

Source: Lauder, 1998

Table 1. Military Injury Mortality, FY 1980 and FY 1996 by Intent and Service

	Deaths per 100,000		
Intent and Service	FY 1980	FY 1996	% Change
Unintentional			
Army	73.6	40.1	-46
Navy	90.5	29.5	-67
Air Force	57.7	21.6	-63
Marines	109.3	63.5	-42
Suicide			
Army	11.1	15.1	+36
Navy	11.6	10.1	-13*
Air Force	10.9	14.7	+35
Marines	14.9	17.7	+19
Homicide			
Army	8.4	4.3	-49
Navy	8.2	5.0	-39
Air Force	3.9	2.8	-28
Marines	16.4	6.3	-62

* The Navy had the highest rate of deaths of undetermined intent (3.9/100,000 for the period 1990-96), a category that typically includes possible suicides.

Source: DIOR, 1997

Abstract

Self-reported risk-taking behaviors and hospitalization for motor vehicle injury among active duty army

Nicole S, Bell NS, Amoroso PJ, Yore MM, Smith GS, Jones BH.

Introduction:

Study Objective: To evaluate the relationship between risky behaviors and motor vehicle injury, and to identify targets for prevention, using a relational database, the Total Army Injury and Health Outcomes Database (TAIHOD) which links self-reported health behaviors, personnel records, hospitalizations and other outcomes.

Background: Motor vehicle injuries are a leading cause of death and disability in the U.S. Army. Studies suggest that behaviors likely to increase risk for motor vehicle injuries, such as heavy drinking, smoking, and speeding, are prevalent among active duty military. However, little research to date has been able to link these behaviors with actual health outcomes.

Methods: Study Population: 95,924 active duty Army personnel who took a Health Risk Appraisal (HRA) survey in 1992 were followed for up to 6 years.

Main Outcome Measure: Motor vehicle related injuries resulting in hospitalization.

Analytic Approach: Associations between hospitalizations for motor vehicle related injuries and self-reported weekly alcohol consumption, drinking and driving, speeding and safety belt use behaviors as well as demographic characteristics are examined using Cox Proportional Hazard models.

Results: 369 of the study population experienced motor vehicle injury hospitalization during the study period with a median length of follow up of 3.56 years from the time of survey administration. Crude (unadjusted) associations between motor vehicle injury and drinking, drinking and driving, speeding, less frequent safety belt usage, younger age, minority race and non-officers were significant.

Smoking habits and gender were not associated with injury risk in this population. In the multivariate model, soldiers under age 21 were injured at 6 times the rate of those over the age of 40. Non-whites had a 71% greater injury risk than whites.

Heaviest drinkers (those drinking more than 21 drinks per week on average) had an 85% increased risk for hospitalization (as compared to non-drinkers). Those who wore their seat

belts least often (50% of the time or less) experienced a 50% greater rate of injury hospitalization as compared to those who wore their belts 100% of the time.

Drinking and driving, speeding and other demographic characteristics were no longer significant in the multivariate model. The overall risk of motor vehicle injury hospitalization, for the group at highest risk (non-white, under age 21, who drank more than 21 drinks per week and wore their safety belt 50% of the time or less) was 5.2 compared to the rest of the population.

Conclusions: Military sub-populations particularly at risk for motor vehicle injury can be identified using the HRA data. Key modifiable risk factors which should be targeted in intervention efforts include heavy drinking and seat belt use. These data also show the utility of the TAIHOD as a research and health promotion tool and the value of being able to link exposure and outcome data from different sources.

CHAPTER 1. LITERATURE REVIEW

The Association Between Musculoskeletal Disorders, Disability, and Smoking: A Review of the Literature

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2 Tables, 1 Figure

Key words: musculoskeletal disorders, natural history, disability, smoking, mechanisms, epidemiology, occupation, military

The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of the Army, Department of Defense, or the U.S. Government

Abstract

Despite the high incidence and costs of musculoskeletal disorders, little is known regarding those factors associated with an increased likelihood of disability. Smoking is one important and often overlooked risk factor that has been suggested to influence the incidence of musculoskeletal disorders and injuries. We examined the epidemiologic evidence relating tobacco use to the incidence of acute injuries or musculoskeletal disorders and their healing and found smoking to be a significant risk factor for low-back pain (OR ranging from 1.2-3.0), lower extremity injury (1.9), carpal tunnel syndrome (1.6), and fracture/non-union (4.1-7.9). In addition, potential physiological and psychosocial mechanisms are assessed and explanations were found to suggest how tobacco could also influence the risk of subsequently developing a physical disability. We propose a multifactoral model that illustrates the factors that influence the transition from musculoskeletal disorder to physical disability. A better understanding of potential predictors of disability, such as tobacco use, will be necessary to identify potential interventions and minimize the long-term sequelae associated with musculoskeletal disorders.

Chapter 3

The Natural History and Risk Factors of Musculoskeletal Conditions Resulting in Disability Among U.S. Army Personnel

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7 Tables, 3 Figures

Key words: musculoskeletal conditions, natural history, disability, epidemiology, occupation, military

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ABSTRACT

Purpose: To describe the natural history of 13 common musculoskeletal conditions that required hospitalization of U.S. Army personnel and identify factors most strongly associated with subsequent development of disability resulting in discharge from the Army.

Design: A retrospective cohort design involving five linked databases was utilized to assess the roles of demographic, behavioral, psychosocial, occupational, and clinical characteristics in the development of physical disability. Subjects included 15,268 U.S. Army personnel hospitalized for common musculoskeletal conditions between the years 1989-1996 who were followed through 1997.

Results: The overall disability discharge rate was 9.5/100 initial hospitalizations for musculoskeletal conditions. Back conditions had the greatest five year cumulative risk of disability following hospitalization (21%, 19%, and 17% for intervertebral disc displacement, intervertebral disc degeneration, and nonspecific low back pain, respectively). Cox proportional hazards models identified the following risk factors for disability among males: lower pay grade, musculoskeletal diagnosis, shorter length of service, older age, occupational category, lower job satisfaction, recurrent musculoskeletal hospitalizations, heavy cigarette smoking, greater work stress, and heavy physical demands. Among females, fewer covariates reached statistical significance, although lower education level was found to be predictive.

Conclusion: Musculoskeletal conditions requiring hospitalization represent a substantial risk of disability discharge from the U.S. Army. Back conditions are the

most severe and have the highest 5 year cumulative risk of disability. Demographic, behavioral, psychosocial, occupational, and clinical characteristics are associated with disability discharge. Modifiable risk factors such as job satisfaction, work stress, and smoking suggest possible targets for intervention.

Chapter 4

The Effect of Cigarette Smoking on Musculoskeletal-Related Disability

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5 Tables, 3 Figures

Key words: musculoskeletal disorders, disability, cigarette smoking, military

ABSTRACT

Purpose: To describe the effect of cigarette smoking on the development of physical disability among persons hospitalized with a musculoskeletal disorder; to determine whether smoking affects disability from different diagnoses to varying degrees; and to suggest mechanisms of smoking's effects based on the findings.

Design: A retrospective cohort design involving 5 linked databases was utilized to follow U.S. Army personnel from their initial musculoskeletal-related hospitalization, which occurred between the years 1989 and 1996, through to the subsequent development of physical disability as indicated by a disability-related discharge, up to 1997. We assessed the effect of different levels of smoking while controlling for demographic, psychosocial, occupational, and clinical characteristics. Subjects included 15,140 U.S. Army personnel hospitalized for one of 13 common musculoskeletal disorders.

Results: Results of this study indicate an association between smoking level and disability discharge for all musculoskeletal categories combined. Kaplan-Meier estimates illustrated distinct survival curves among different smoking levels and log-rank tests for trend demonstrated associations between smoking level and cumulative risk for disability discharge for all knee disorders (e.g., meniscal injury ($p<0.001$), cruciate ligament injury ($p=0.08$), collateral ligament injury ($p=0.003$), and chondromalacia ($p=0.03$)), rotator cuff injury ($p=0.01$), and intervertebral disc displacement ($p=0.05$). However, when adjusting for stronger predictors in multivariate Cox proportional hazards models, smoking was significantly associated

with only meniscal injuries (light smokers (<1 pack/day) had a 44% greater risk than nonsmokers and heavy smokers (1+ pack/day) had a 49% greater risk) and all diagnostic categories combined (heavy smokers had a 21% greater risk). Former smokers appear to be protected, though not significantly (RH=0.94, 95% CI: 0.80, 1.11). Among current smokers with meniscal injuries, 38% of disability discharges were attributable to smoking, while the attributable risk of disability due to smoking among current smokers and nonsmokers was 18%.

Conclusion: Results provide evidence of an association between heavy smoking and the development of disability following hospitalization for musculoskeletal disorders in the U.S. Army. A potential biologic mechanism to explain smoking's effect on meniscal injuries may involve smoking's effect of reducing blood flow to the already limited vascularization of the meniscus. The finding suggests that medical management of patients with various musculoskeletal disorders, and in particular meniscal injuries, should address cigarette smoking to reduce the risk of subsequently developing a physical disability.

HOSPITALIZED OCULAR INJURIES IN THE UNITED STATES ARMY - 1985-1994.

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James Tielsch, Ph.D.

Purpose: To determine the incidence of hospitalized ocular injury in the United States Army, to identify time trends, to define high risk demographic factors and to evaluate specific types and external causes of these injuries.
Design and setting: Hospital discharge database of all U.S. Army servicemen
Methods: An Army-wide hospital discharge database was used to determine incident episodes of ocular injury requiring hospitalization for the ten year period, 1985-1994. Denominator data were available from the Army's Defense Manpower Data Center.
Results: The average annual incidence of hospitalization for a principal diagnosis of ocular trauma was 50.0 per 100,000 (95% confidence interval [CI], 48.5, 51.8) while the incidence for a principal or secondary diagnosis of ocular trauma was 77.1 per 100,000 (95% CI, 75.1, 79.2). There was a 62% decline in the rate of ocular trauma requiring hospitalization over this ten year period. Males were twice as likely to be hospitalized for ocular injury than females over all age groups. The highest rate of injury occurred in the 15-19 years old age group, with rates of 220.7 and 123.4 per 100,000 in males and females respectively. Males aged 15-19 had almost 20 times higher risk than females aged 40-44. Whites had a higher rate of injury compared to blacks and nonwhites-nonblacks. Almost a third of the injuries were contusions of the eye and adnexa. The single most common cause of ocular injury was fighting (n=1001 hospital admissions, 18.4% of total). Nearly 50% of injuries were incidents related to machinery / tool usage, motor vehicles and sports. Non battle incidents accounted for 90% of injuries associated with war or weaponry. Half of all ocular injuries were admitted for three or more hospital days.
Conclusions. There is a high incidence of severe ocular injury in the U.S. Army, which has significant implications from medical, economic and military perspectives.

FREQUENCY TABLE OF GENDER BY CASUALTY MANNER BY CASUALTY YEAR

DATA SOURCE: 10/89 - 09/96 MILITARY MORTALITY DATA

CONTROLLING FOR SEX=FEMALE

CAS_MANN(Casualty Manner) YEAR

Frequency Percent Row Pct Col Pct	89	90	91	92	93	94	95	96	Total
ACCIDENT	10 1.89 4.15 52.63	34 6.44 14.11 43.04	52 9.85 21.58 53.61	29 5.49 12.03 42.03	23 4.36 9.54 34.33	31 5.87 12.86 44.93	37 7.01 15.35 42.05	25 4.73 10.37 62.50	241 45.64
HOSTILE ACTION	0 0.00 0.00 0.00	0 0.00 0.00 0.00	5 0.95 100.00 5.15	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	5 0.95
HOMICIDE	2 0.38 2.35 10.53	13 2.46 15.29 16.46	12 2.27 14.12 12.37	14 2.65 16.47 20.29	11 2.08 12.94 16.42	11 2.08 12.94 15.94	17 3.22 20.00 19.32	5 0.95 5.88 12.50	85 16.10

Frequency Percent Row Pct Col Pct	89	90	91	92	93	94	95	96	Total
ILLNESS	2 0.38 1.87 10.53	18 3.41 16.82 22.78	17 3.22 15.89 17.53	13 2.46 12.15 18.84	21 3.98 19.63 31.34	14 2.65 13.08 20.29	17 3.22 15.89 19.32	5 0.95 4.67 12.50	107 20.27
DETERMINATION PENDING	0 0.00 . 0.00	0 0.00 . 0.00	0 0.00 . 0.00	0 0.00 . 0.00	0 0.00 . 0.00	0 0.00 . 0.00	0 0.00 . 0.00	0 0.00 . 0.00	0 0.00
SUICIDE	5 0.95 7.14 26.32	12 2.27 17.14 15.19	9 1.70 12.86 9.28	11 2.08 15.71 15.94	9 1.70 12.86 13.43	10 1.89 14.29 14.49	11 2.08 15.71 12.50	3 0.57 4.29 7.50	70 13.26
TERRORIST ACTIVI	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	4 0.76 100.00 4.55	0 0.00 0.00 0.00	4 0.76
UNKNOWN	0 0.00 0.00 0.00	2 0.38 12.50 2.53	2 0.38 12.50 2.06	2 0.38 12.50 2.90	3 0.57 18.75 4.48	3 0.57 18.75 4.35	2 0.38 12.50 2.27	2 0.38 12.50 5.00	16 3.03
Total	19 3.60	79 14.96	97 18.37	69 13.07	67 12.69	69 13.07	88 16.67	40 7.58	528 100.00

CONTROLLING FOR SEX=MALE

CAS_MANN(Casualty Manner)   YEAR

Frequency Percent Row Pct Col Pct	89	90	91	92	93	94	95	96	Total
ACCIDENT	197 2.31 4.32 53.53	844 9.89 18.50 59.10	878 10.29 19.25 51.95	646 7.57 14.16 52.78	603 7.07 13.22 52.62	510 5.98 11.18 50.70	497 5.83 10.90 52.21	386 4.52 8.46 53.76	4561 53.46
HOSTILE ACTION	23 0.27 13.61 6.25	1 0.01 0.59 0.07	143 1.68 84.62 8.46	1 0.01 0.59 0.08	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	1 0.01 0.59 0.14	169 1.98
HOMICIDE	19 0.22 3.79 5.16	60 0.70 11.98 4.20	99 1.16 19.76 5.86	93 1.09 18.56 7.60	74 0.87 14.77 6.46	71 0.83 14.17 7.06	50 0.59 9.98 5.25	35 0.41 6.99 4.87	501 5.87

Frequency Percent Row Pct Col Pct	89	90	91	92	93	94	95	96	Total
ILLNESS	65 0.76 4.31 17.66	260 3.05 17.24 18.21	289 3.39 19.16 17.10	235 2.75 15.58 19.20	200 2.34 13.26 17.45	188 2.20 12.47 18.69	150 1.76 9.95 15.76	121 1.42 8.02 16.85	1508 17.67
DETERMINATION PENDING	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	1 0.01 14.29 0.10	5 0.06 71.43 0.53	1 0.01 14.29 0.14	7 0.08
SUICIDE	59 0.69 3.82 16.03	219 2.57 14.19 15.34	239 2.80 15.49 14.14	215 2.52 13.93 17.57	221 2.59 14.32 19.28	219 2.57 14.19 21.77	234 2.74 15.17 24.58	137 1.61 8.88 19.08	1543 18.08
TERRORIST ACTIVI	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	29 0.34 56.86 2.53	0 0.00 0.00 0.00	3 0.04 5.88 0.32	19 0.22 37.25 2.65	51 0.60
UNKNOWN	5 0.06 2.60 1.36	44 0.52 22.92 3.08	42 0.49 21.88 2.49	34 0.40 17.71 2.78	19 0.22 9.90 1.66	17 0.20 8.85 1.69	13 0.15 6.77 1.37	18 0.21 9.38 2.51	192 2.25
Total	368 4.31	1428 16.74	1690 19.81	1224 14.35	1146 13.43	1006 11.79	952 11.16	718 8.42	8532 100.00